ASSESSMENT AND PRIORITIZATION OF STREAMS IN LIBERTY RESERVOIR, MATTAWOMAN CREEK, AND PRETTYBOY RESERVOIR WATERSHEDS IN NEED OF RESTORATION AND PROTECTION

CHESAPEAKE BAY AND
WATERSHED PROGRAMS
MONITORING AND
NON-TIDAL ASSESSMENT

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Final Data Report:

Assessment and Prioritization of Streams in Liberty Reservoir, Mattawoman Creek, and Prettyboy Reservoir Watersheds in Need of Restoration and Protection

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Introduction

This work was completed by the Maryland Department of Natural Resources, Resource Assessment Service, Monitoring and Non-Tidal Assessment Division under contract number M01-053 CZM 040.

In response to former President Clinton's Clean Water Action Plan, Maryland completed it's first Unified Watershed Assessment (UWA) during 1998. The UWA identified Maryland watersheds (8-digit) most in need of restoration and protection. This report is the first in a series of annual reports using results from the Maryland Biological Stream Survey (MBSS) to assist in the prioritization of specific areas within the 8-digit priority watersheds identified by the UWA. This finer scale analysis can be used to target limited funds within each watershed so that they provide the maximum benefit to stream resources. This report also provides a list of the probable stressors to biota in these specific areas. Knowledge of the stressors to a given stream system can be used to focus restoration efforts on parameters that should provide the greatest likelihood for success.

This first of five annual reports covers three watersheds: Liberty Reservoir, Prettyboy Reservoir, and Mattawoman Creek. According to the UWA, all three of these watersheds show signs of stress, but still contain sensitive natural resources. Therefore, they are in need of both protection and restoration.

The goal of this report is to provide guidance for targeting resource management initiatives within each of these three UWA priority watersheds. This targeting includes the identification of areas most in need of restoration and protection as well as a diagnosis of probable stressors to ecological resources in areas where restoration is needed. Although this information pertains exclusively to ecological resources, it is hoped that it will be considered as part of a comprehensive restoration and protection plan.

Methods

A total of 237 sampling sites were used to characterize stream conditions and identify potential stressors to stream resources in the Liberty Reservoir, Prettyboy Reservoir, and Mattawoman Creek watersheds (Figures 1-3). Fish, benthic macroinvertebrate, herpetofauna, physical habitat, chemical, and land use data were collected from a total of 58 randomly selected sampling sites in the Liberty Reservoir watershed, 19 in the Prettyboy Reservoir watershed and 38 in the Mattawoman Creek watershed as part of the Maryland Biological Stream Survey (MBSS) conducted by the Maryland Department of Natural Resources (DNR) between 1995 and 2000. Benthic macroinvertebrate data were collected from an additional 52 non-randomly selected sites in the Liberty Reservoir watershed, 18 sites in the Prettyboy Reservoir watershed, and 51 sites in the Mattwoman Creek watershed during 2000 as part of the Stream Waders volunteer monitoring program coordinated by DNR. This broad sampling density provides the opportunity for conducting overall watershed assessments. Despite this major monitoring effort, however, only 1.4 percent of the total miles of streams in these watersheds were sampled by MBSS, with an additional 1.5 percent sampled by Stream Waders volunteers. The presence of minimally degraded conditions, rare or unique resources, or severe degradation in any unsampled stream reaches can not be ruled out. A more comprehensive survey of the streams in the watershed would be necessary to provide a complete inventory of resources and conditions. However, results of the MBSS and Stream Waders sampling efforts offer useful insights into the health of non-tidal streams in these three watersheds.

MBSS (Kazyak 2000) and Stream Waders (MDNR 2001) monitoring and assessment methods are described below:

Fish

Fish assemblage data were collected using double-pass electrofishing with direct current backpack units. Each 75 m long site was blocked at each end using 0.25 inch mesh, block nets and all available habitats were thoroughly sampled. For each pass, all captured fish were identified to species, counted, and released. Fishes were collected during summer (June - September) to avoid the effects of spring and fall spawning movements on fish assemblages and to maximize electrofishing catch efficiencies. Fish data were analyzed in terms of species richness, composition, relative abundance, and general pollution tolerance. A Fish Index of Biotic Integrity (FIBI) was also calculated (Roth et al. 1998; Roth et al. 1999). Stressors to the fish assemblage at each site were diagnosed based on relationships between stressor variables and fish species presence and absence previously documented by the MBSS (Stranko et al. 2001).

Benthic Macroinvertebrates

Benthic macroinvertebrates were collected by Stream Waders volunteers and MBSS biologists using D-frame sampling nets during spring (March-April). A 100 organism sub-sample of the benthos collected at each site was processed and identified by DNR staff for both programs. MBSS samples were identified to genus taxonomic level and Stream Waders samples were identified to family taxonomic level. These data were used to calculate a genus level and family-level benthic macroinvertebrate index of biotic integrity (BIBI) respectively for each site.

Rare, Threatened, and Endangered Taxa

Any fish species identified by DNR's Natural Heritage Division as rare, threatened, or endangered based on the official State Threatened and Endangered Species List as part of the State of Maryland Threatened and Endangered Species regulations (COMAR 08.03.08) was noted.

Water Quality

MBSS water chemistry sampling occurred during the spring of each sampling year (March - April). Water samples were analyzed for a suite of parameters which included closed pH, specific conductance, acid neutralizing capacity, dissolved organic carbon, sulfate, and nitrate.

Additional sampling of water quality occurred during the summer of each sampling year when *in situ* measurements were made just prior to fish sampling. Prior to 2000, parameters measured included dissolved oxygen (DO), pH, conductivity, and temperature. During 2000, turbidity was added to the suite of summer sampling measurements. All measurements were taken with a Hydrolab™ multiprobe water quality meter, except for turbidity which was measured with a

LaMotte™ turbidity meter. Both instruments were calibrated before sampling according to MBSS QA/QC guidelines (Kazyak 2000).

Water Temperature
Temperature loggers were placed at all MBSS sites during 2000. The loggers recorded water temperature every 15 minutes from 1 June through 15 September. Maximum temperatures over this period were reported for each site sampled during 2000. Prior to 2000 only one time temperature data were taken during summer base-flow. The one time temperature measurements are reported for sites sampled prior to 2000. Maryland freshwater streams are designated for different levels of protection from thermal impacts depending on the classification of the stream by the Maryland Department of the Environment (COMAR 26.08.02). See Appendix A for details regarding stream designated use classes.

Physical Habitat
Physical habitat assessments were conducted to evaluate habitat effects on biota. MBSS habitat assessment procedures were derived from two methods: EPA's Rapid Bioassessment Protocols (Plafkin et al. 1989), as modified by Barbour and Stribling (1991), and Ohio EPA's Qualitative Habitat Evaluation Index (Ohio EPA 1987). Several parameters (instream habitat, epifaunal substrate, velocity/depth diversity, pool/glide/eddy quality, riffle quality, embeddedness, and shading) were scored based on visual observations. Quantitative measurements at each site included the number of woody debris and root wads, maximum depth, wetted width, depth, and discharge. Bank stability and stream channelization were scored based on visual observations at sites sampled prior to 2000. During 2000, measurements of the amount and severity of erosion replaced the bank stability visual assessment and measurements of the linear extent of channelized stream and type of channelization replaced the channelization visual assessment.

Landscape
The landscape surrounding a watershed can have a profound influence on the physical habitat structure, chemistry, and biology of it's streams. Some potentially important landscape scale factors including watershed area, physiography, geology, and soil type were described for each watershed. These factors are important in interpreting many biological, physical, and chemical findings, other than those related to human influences on streams. An additional landscape variable (land use) is also provided and can be used to investigate influences of human activities on stream ecological resources.

Land Use
Arc View software was used to generate site-specific land use and impervious surface information for the catchment (land area draining to a stream from upstream) of each MBSS site using U.S. EPA Multi-Resolution Land Characteristic Consortium (MRLC) data. These land use data are based on Landsat ™ data acquired between 1986-1993 and, as a result, ***do not reflect land use changes that have occurred since 1993***.

Quality Control/ Quality Assurance
Quality control and quality assurance procedures for this project followed the MBSS methods. These procedures have been accepted by the U.S. Environmental Protection Agency and meet all requirements as outlined in "The Guidelines and Specifications for Preparing Project Plans", EPA QAMS 005/80.

Protection and Restoration Priorities
For the purpose of this report, all of the land area draining to a site on a stream is defined as the site catchment. The physical, chemical, and biological conditions of a stream site depend on the conditions (land use and land cover) of the site catchment. Anthropogenic influences to land such as urbanization, agriculture, mining, and logging dramatically alter the ecological conditions of a stream site. All land in Maryland has been (either historically or recently) anthropogenically altered to some degree. Consequently, all streams in Maryland have also been anthropogenically altered to some degree. However, streams have been altered to lesser or greater degrees depending on the type and extent of land use alterations that have occurred in their catchments. Although the effects of historic alterations can be perpetual, in many cases, recent alterations probably affect streams more than historic alterations. The inherent ability of a stream to withstand the influence of anthropogenic alterations to the landscape is also important. Streams that presently exhibit conditions indicative of relatively minimal anthropogenic alterations are termed minimally-degraded in this report. Minimally-degraded stream conditions are often manifested as Good IBI (scores greater than 4.0 on a scale of 1.0-5.0 with 5.0 being the best possible score). Moderately-degraded streams typically exhibit Fair IBI scores (3.0-3.9) and degraded and severely-degraded streams typically score in the Poor (2.0-2.9) or Very Poor (1.0-1.9) range respectively.

<u>Protection</u>
A three tiered approach was used to prioritize land area within each of the three watershed covered by this report for protection. IBI scores at MBSS sites were the basis for prioritizing an area for protection. Due to the influence of land use and land cover alterations on stream quality, catchments (land area draining) of MBSS sites with Good IBI scores (minimally-degraded conditions) were given top priority for protection. The second tier priority for protection included catchments of MBSS sites with Fair IBI scores (moderate degradation). The third, lowest, tier priority for protection includes sites that are degraded or severely degraded (Poor IBI scores).

<u>Restoration</u>
A similar three tiered approach was used to prioritize stream reaches for restoration within each watershed. The top priority for restoration was designated to stream reaches in catchments that have been prioritized for protection. Since all streams in Maryland have been anthropogenically altered to some degree, stream reaches in catchments that have been prioritized for protection can also benefit from restoration. In many cases, the minimally degraded status of a site can only be maintained by improving stream conditions through restoration initiatives in its catchment. Conditions may actually improve in many minimally-degraded streams as a result of restoration in their catchments. There is also a greater potential for restoration success in minimally degraded catchments compared to severely degraded catchments because severely degraded catchments often suffer from the influence of a greater number of stressors. In

addition, fewer reaches should need to be restored in minimally-degraded catchments. The second tier priority for restoration included stream reaches in catchments of MBSS sites with moderate degradation (Fair IBI scores). Finally, unless the impairment presents a human health hazard, we recommend that restoration work on the third tier (severely-degraded sites with Poor IBI scores) be deferred until stream segments in higher priority catchments are restored.

Many stream reaches in priority protection catchments also in need of restoration have already been identified by the presence of an MBSS or Stream Waders sampling site. Poor IBI scores as well as data on severe or extensive bank erosion or insufficient vegetated riparian buffers and poor physical habitat ratings are available at MBSS sites and can be used to target stream reaches in need of restoration. Poor IBI scores at Stream Waders sites can also be used to find stream reaches within priority protection catchments that may also be in need of restoration. Good IBI scores at an MBSS or Stream Waders site in a priority protection catchment indicates that restoration may not be necessary in that particular stream segment where the sampled site with the Good score is located. Neither the MBSS nor the Stream Waders program has sampled every reach of every stream in all priority protection catchments. Thorough surveys of habitat and water quality in all reaches of priority catchments are needed to find additional stream reaches where restoration may be necessary.

Potential Point Sources of Pollution

Potential sources of pollution to streams in each watershed from point sources were identified based on data from the National Pollutant Discharge Elimination System (NPDES) Program as administered by the U.S. Environmental Protection Agency (USEPA). The NPDES Program gives permits to facilities to discharge a specified amount of a pollutant into a receiving water under certain conditions. Permits are given to two types of facilities: municipal and industrial. Municipal sites are point where publicly-owned treatment works receive sewage from both residential and commercial sources. Processes at these sites often produce wastewater and sludge. Industrial sites are points that discharge wastewater from industrial facilities. Pollutants that are discharged vary widely and depend primarily on the type of industry that exists.

Good Quality or Degraded Variables

Select water quality, physical habitat, land use, and biological variables sampled at each MBSS site were listed on tables for each watershed. Cells on the tables with values indicating the presence of severe degradation were outlined with a thick black line. Cells with values indicating good quality (minimally degraded), rare, or unique stream resources were highlighted in gray. Appendix A shows thresholds for classifying values as good quality or severely degraded.

Stressors to Biota

In addition to the identification of variables that may be indicative of degradation to each site, probable stressors to fish species at MBSS sites were diagnosed based on relationships previously documented by the MBSS. This method compares a list of the fish species expected to occur at an MBSS site with the species actually collected. Specific variables with values that were outside of the tolerance range for the expected but absent species at a site were listed as probable stressors to those species at that site. Several physical, chemical and land use variables were identified as probable stressors to fishes using this approach. All possible physical and chemical conditions could not be measured at MBSS sites and many that were measured were only measured one time and may not reflect the most severe conditions for biota. Therefore, the identification of land-use stressors is directly related to sensitivity of fishes to physical and chemical conditions that are likely to be more severe than reflected by other variables as a result of the conversion of land to impervious parking lots and roads or agricultural crops and pastures. Although sampling by the MBSS includes a large number of probable stream stressors, many variables not measured by the MBSS may be influencing fishes and were not detected. Discrete, one-time sampling by the MBSS may also miss important measurements that may be acting as stressors to stream biota.

Results/Discussion

Results are presented by watershed. Maps depicting areas prioritized for restoration and protection are presented first (Figures 4-6). Possible point sources of pollution based on facilities with NPDES permits are shown on watershed maps (Figures 7-9). Tables that list select variables sampled at each site with values indicative of degradation outlined with a thick black line and values indicative of good quality highlighted in gray (Tables 1-3) follow the maps. Probable stressors to fishes at each site are listed in Tables 4-6. Maps and tables showing MBSS site locations, geographic coordinates, and stream names are on Appendix B and can be used to locate specific stream sites within each watershed that have been identified as needing management initiatives.

Liberty Reservoir

Landscape

The Liberty Reservoir watershed is located in Baltimore and Carroll Counties, Maryland, and encompasses 104,804 acres. It is located within the Piedmont physiographic province. The primary geologic strata in the area consist of quartz, feldspar, and clay-rich rock/sediment. These rock types tend to provide relatively little acid-neutralizing capacity (McCartan et. al. 1998). The southern portion of the watershed also contains iron, magnesium, and calcium-rich (mafic) rock/sediment. This geologic formation tends to result in moderately hard water. Soils in the watershed primarily consist of silt with varying proportions of sand and clay. The dominant land use in the watershed is agriculture (46%), followed by forest (32%), urban (18%), and water/wetlands (3%). Liberty Reservoir supplies drinking water for Baltimore City. As a result, much of the land area immediately surrounding the reservoir is owned by the City of Baltimore and is maintained as forested land to protect the quality of the drinking water.

Protection and Restoration Priorities

A large number of sampling sites (31, 53%) in this watershed were minimally degraded conditions (received Good scores) for the fish or benthic macroinvertebrate IBIs. The streams in the catchments draining to these sites were given priority for protection and restoration (Figure 4). The result is the prioritization of most of the watershed. Seven sites on six streams including Timber Run, Cooks Branch, Middle Run, Roaring Run, the East Branch of the Patapsco River, and an unnamed tributary to Little Morgan Run had both fish and benthic IBI scores in the good range. Focusing restoration and protection on catchments of these streams first may provide the most widespread ecological benefit to the watershed. A single specimen of glassy darter (*Etheostoma vitreum*), an endangered species of fish was collected at one site near the downstream end of Morgan Run. This was the only site in Morgan Run where a glassy darter has ever been documented. It is also the only one of six sites sampled by the MBSS in Morgan Run where a glassy darter was collected. The finding is also a long distance (greater than 50 miles) from the present known distribution of glassy darters in Maryland. Although the presence of this specimen warrants additional monitoring in Morgan Run, sufficient data are not available to believe that a viable population of endangered glassy darters exists there. Therefore, no special prioritization of the site where the glassy darter was collected is recommended in this report. Many sites showing degradation by MBSS and Stream Waders were located in catchments that were prioritized for protection and restoration. These degraded sites could be a basis for beginning to locate specific areas within priority protection watersheds that require restoration.

Potential Point Sources of Pollution

A total of eleven NPDES permits have been issued to facilities in the Liberty Reservoir watershed. Of these, six (55%) discharge into catchments that have been identified as top priorities for protection and restoration (Figure 7).

Good Quality or Degraded Variables

The majority of FIBI and BIBI scores were in the Good or Fair range (above 3.0 on a scale of 1-5) in the watershed indicating that human influences to biota are likely to be minimal in most places. Only two sites scored Poor (less than 3.0) for the FIBI (3%) and sixteen (28%) scored poor for the BIBI. The relatively small amount of urbanization and abundance of physical habitat structure in most of the streams in this watershed were also indicative of minimal degradation. The most common kinds of degradation present in the Liberty Reservoir watershed appear to be the large amount of agricultural land use, followed by bank erosion, and insufficient vegetated riparian buffers (Table 1). Water temperature in many of the streams within this watershed were also elevated. According to temperature logger data collected during 2000, water temperature exceeded the maximum allowable temperature for all streams in the watershed designated as natural trout waters(Use Class III; 20.0 ^{o}C) for a minimum of five hours in Timber Run and a maximum of ten hours in Cooks Branch. This indicates that the trout in the Liberty Reservoir watershed may be experiencing severe thermal stress in most streams where they reside.

Stressors to Biota

Brook trout (*Salvelinus fontinalis*) absence in many sites (13) in the Liberty Reservoir watershed corresponded to a number of variables that were outside of the range of tolerance for brook trout (Table 4). This suggests that brook trout was more widely distributed in this watershed prior to the influence of many of these stressors than they are now. Creek chub (*Semotilus atromaculatus*), rosyside dace (*Clinostomus funduloides*), white sucker (*Catostomus commersoni*), cutlips minnow (*Exoglossum maxillingua*), margined madtom (*Notorus insignis*), and river chub (*Nocomis micropogon*) distributions were also affected by anthropogenic stressors. The most prevalent stressors corresponding to fish species absence where they were expected to occur in the Liberty Reservoir watershed included impervious land cover in stream catchments, agriculture land use, and nitrates. Riffle embeddedness, loss of canopy shading, excessive temperature, and bank erosion were also important stressors.

Summary

The majority of streams in the Liberty Reservoir watershed appear to be minimally degraded by anthropogenic sources. These conditions can only be maintained by protecting the minimally degraded areas of the watershed from additional anthropogenic influence. Restoration of degraded streams is also necessary to maintain minimally degraded conditions and is likely to improve conditions in even the least degraded streams. Non-point source degradation from agriculture and urban development seem to be having the greatest negative influence on the ecology of this watershed. Stream bank stabilization, riparian buffer planting projects, and nutrient reduction initiatives should provide some protection to stream resources. However, limiting urban development in minimally degraded catchments and providing sufficient vegetated riparian buffers along streams where farming occurs are likely to provide the greatest long term benefit.

<u>PrettyBoy Reservoir</u>

Landscape

The Prettyboy Reservoir watershed is located in Baltimore and Carroll Counties, Maryland, and encompasses 46,455 acres. It is located within the Piedmont physiographic province. The geology and soils of the Prettyboy Reservoir watershed are similar to the Liberty Reservoir watershed. The primary geologic strata in the area consist of quartz, feldspar, and clay-rich rock/sediment. These rock types tend to provide relatively little acid-neutralizing capacity (McCartan et. al. 1998) Soils in the watershed primarily consist of silt with varying proportions of sand and clay. The dominant land use in the watershed is agriculture (50%), followed by forest (36%), urban (10%), and water/wetlands (4%). Like Liberty Reservoir, Prettyboy Reservoir also supplies drinking water for Baltimore City. As a result, much of the land area immediately surrounding the reservoir is owned by the City of Baltimore and is maintained as forested land to protect the quality of the drinking water.

Protection and Restoration Priorities

A total of 13 (68%) sampling sites in this watershed had Good scores for the fish or benthic macroinvertebrate IBIs. The streams in the catchments draining to these sites, including George’s Run, Gunpowder Falls upstream of Prettyboy Reservoir, Murphy Branch, Piney Branch, Preggy’s Run, South Branch of Gunpowder Falls, Prettyboy Branch, Grave Run, Compass Run, Poplar Run, and a tributary to Little Falls Run, were given priority for protection and restoration (Figure 5). No sites had both fish and benthic IBI scores in the Good range.

Potential Point Sources of Pollution

Only one municipal NPDES permit has been issued to the town of Manchester in the Prettyboy Reservoir watershed. This permit allows discharge in the vicinity of George’s Run. The catchment of this stream has been identified in this report as warranting protection and restoration (Figure 8).

Good Quality or Degraded Variables

Half of the FIBI scores (8) and five (26%) of the BIBI scores in this watershed were in the Good range (Table 2). Only two sites scored Poor for both the FIBI (13%) and the BIBI (11%). Urban land use, amounts of impervious surface, and instream habitat at most sites in this watershed were indicative of healthy streams. The most common kind of degradation in streams of the Prettyboy Reservoir watershed appears to be a large amount of agricultural land use. Bank erosion and a lack of sufficient vegetated riparian buffers are also prevalent problems. Many MBSS sites with these kinds of degradation were located in watersheds that were prioritized for protection and restoration. These sites along with degraded Stream Waders sites could provide a basis for locating specific areas within priority protection watersheds that require restoration. The temperature in most of the streams within the watershed was also problematic for cold water fish species. According to the Maryland Department of the Environment (COMAR 26.08.02), all streams in this watershed are designated as natural trout waters (Use Class III) and temperatures should not exceed 20.0 ^{o}C. Temperature logger data measured by the MBSS during 2000 indicated that temperatures exceeded this maximum at all streams sampled in the watershed. Duration of time the stream temperatures exceeded 20.0^{o}C ranged from 2 hours in Prettyboy Branch to 17 hours in Peggy's Run. According to MBSS monitoring, many streams in this watershed no longer support reproducing trout and those streams that presently hold trout are likely to be experiencing severe thermal stress.

Stressors to Biota

The majority of sites where probable stressors were diagnosed in the Prettyboy Reservoir watershed were identified as influencing brook trout (Table 5). Brook trout were absent from a number of sites where they were expected to occur. Excess nitrate was the potential stressor that was most often associated with brook trout absence. A clear cause and effect relationship between elevated nitrate levels and brook trout demise is difficult to explain. Nitrate levels were not high enough at any site to suggest that they had a direct toxic affect on brook trout. Absence of brook trout associated with high nitrate levels is based on MBSS sampling of 955 sites during 1995-1997. The MBSS never collected any brook trout in any stream where the nitrate measurement was above 5.0 mg/l. Agriculture land use was also identified as a reason for brook trout absence where they were expected to occur. Three other species of fish (margined madtom, swallowtail shiner (*Notropis procne*), and cutlips minnow) were also absent as a result of agriculture land use. Fish species absences corresponding to high nitrate levels and agriculture land use may indicate that nutrient levels could be high enough in these stream to cause primary productivity to periodically increase, which could in turn depress dissolved oxygen levels and make the stream inhospitable to some species.

Summary

The condition of streams and the dominant stressors on streams in the Prettyboy Reservoir watershed were very similar to those in the Liberty Reservoir watershed. The majority of streams in the Prettyboy Reservoir watershed appear to be minimally-degraded by anthropogenic sources. These conditions can only be maintained by protecting the minimally degraded areas of the watershed from additional anthropogenic influence. Restoration of degraded streams is also necessary to maintain minimally-degraded conditions and improve conditions in many streams. Non-point source degradation from agriculture and urban development seem to be having the greatest negative influence on the ecology of the watershed. Stream bank stabilization, riparian buffer planting projects, and nutrient reduction initiatives should provide some protection to stream resources. However, limiting urban development in minimally-degraded catchments and providing sufficient vegetated riparian buffers along streams where farming occurs are likely to provide the greatest benefit.

Mattawoman Creek

Landscape

The Mattawoman Creek watershed is located in Charles and Prince George's Counties, Maryland, encompasses 62,192 acres and is entirely within the Coastal Plain physiographic province. The primary geologic strata in the area consist of mixtures of mud, clay, quartz, silt, sand weathered residium, organic rich deposits (including peat), and iron rich greensand. These rock types tend to provide relatively little acid-neutralizing capacity. Iron rich rock types may provide iron to stream water (McCartan et. al. 1998). Sand is the dominant soil type in the Mattawoman Creek watershed. Silt, clay, and gravel are also abundant. These geology and soil types are highly porous. As a result, streams in the watershed may have low base-flow compared to streams that flow through other geologic areas. The dominant land use in the watershed is forest (62%), followed by urban (22%), agriculture (14%), and water/wetlands (1%).

Protection and Restoration Priorities

Only ten (26%) sampling sites in this watershed had Good scores for the fish or benthic macroinvertebrate IBIs. The streams in the catchments draining to these ten sites, including Piney Branch, Old Woman's Run, Marbury Run, Mattawoman Creek near the Myrtle Grove Wildlife Management Area, and three tributaries in the southwestern portion of the watershed should receive high priority for protection and restoration (Figure 6). Four sites on four streams including Mattawoman Creek, Piney Branch, Marbury Run, and an unnamed tributary had both fish and benthic IBI scores in the Good range.

Potential Point Sources of Pollution

A large number (39) of industrial NPDES permits have been issued in the vicinity of the Indian Head Naval Surface Warfare Center (NSWC). All of these discharges enter the tidal portion of the Mattawoman Creek watershed near the confluence with the Potomac River. None of the industrial NPDES permit discharges are located within areas prioritized for protection in this report. The Brandywine Receiving Station and the Gale Bailey Elementary school have municipal NPDES permits to discharge and are located within priority catchments (Figure 9).

Good Quality or Degraded Variables

Less than one quarter of the stream sites sampled in the Mattwoman Creek watershed scored in the Good range for the benthic macroinvertebrate or fish IBIs (21% and 24% respectively). Nearly half of the sites scored in the poor range for these two indices (49% and 46% respectively). Although amounts of urbanization and impervious surface were in the ranges that are generally indicative of healthy streams at most of the sites in this watershed, the percent of impervious surface exceeded levels indicating impacts at four sites (i.e., >10%). The most prevalent kinds of degradation to the Mattawoman Creek watershed appears to be low dissolved oxygen followed by poor instream habitat and insufficient vegetated riparian buffers. Riffle embeddedness, erosion, and pH are also important impacts to streams in portions of this watershed. Many MBSS and Stream Waders sites with severe degradation were located in the catchments of streams identified as in need of protection and could be a basis for beginning to locate areas within priority protection watersheds that require restoration.

Stressors to Biota

A number of fish species including redbreast sunfish (*Lepomis auritus*), American eel (*Anguilla rostrata*), bluespotted sunfish (*Eneacanthus gloriosus*), margined madtom, pumpkinseed (*Lepomis gibbosus*), fallfish (*Semotilus corporalis*), swallowtail shiner, blacknose dace (*Rhynichthys atratulus*), tadpole madtom (*Noturus gyrinus*), pirate perch (*Aphredoderus sayanus*), creek chubsucker (*Erimyzon oblongus*), and sea lamprey (*Petromyzon marinus*) appear to be absent from streams in the Mattawoman Creek watershed due to anthropogenic stressors (Table 6). Acidity, poor pool habitat, high impervious land cover, low dissolved oxygen, and insufficient depth were identified as probable stressors to these fishes.

Summary

Many of the streams in the Mattawoman Creek watershed appear to be degraded. Anthropogenic sources of acidity appear to be dominant stressors. Although many regulations have been implemented to control acid deposition, acid precipitation remains a source of degradation to many areas. This is most likely due to the lack of buffering in the soils of the watershed and may be difficult to solve without imposing additional limits on the sources of acidifying emissions. Degraded stream habitat, low dissolved oxygen, and other impacts resulting from urban run-off and the conversion of land to impervious surface are also important kinds of degradation to streams in the Mattawoman Creek watershed. Stream bank stabilization, riparian buffer planting projects, and nutrient reduction initiatives should provide some improvement to stream resources. However, limiting urban development in many areas is likely to provide the greatest benefit to the watershed.

Conclusions

This report is meant to convey information that could be used to provide the greatest possible benefit to stream ecological resources in three watersheds Liberty Reservoir, Prettyboy Reservoir, and Mattawoman Creek, based on the best monitoring data presently available. This report pertains exclusively to ecological resources and should be considered as part of a comprehensive watershed restoration and protection plan that also considers benefits to social and economic resources.

Specific areas in need of protection or restoration within Liberty Reservoir, Prettyboy Reservoir, and Mattawoman Creek watersheds are identified in this report based on surveys of the watershed by the Maryland Biological Stream Survey (MBSS). However, more comprehensive surveys of stream conditions with higher sample site densities and directed stream walks using methods like DNR's Stream Corridor Assessment survey (Yetman 2000), in the upstream catchments of minimally-degraded streams would provide additional information necessary to plan detailed restoration work that would ensure even greater benefits to streams in these watersheds. Volunteer sampling results from DNRs Stream Waders program are also presented in this assessment to help identify specific sites within areas prioritized for protection that are in need of restoration. With the abundance of biological, physical habitat, and chemical data available from the MBSS and Stream Waders program in the three watersheds, supplemental surveys of stream bank erosion, width of vegetated riparian buffers, and general instream habitat quality could be used to identify areas where buffer planting projects, stream bank stabilization, storm water controls, or other restoration improvements could be implemented. In most cases, we recommend that a long-term, lower cost approach to stream habitat improvements such as riparian buffer planting projects be evaluated first before expensive channel modifications are considered. Ecological monitoring that includes the collection of biological, physical habitat, and chemical conditions throughout these priority watersheds should continue to be conducted on a regular basis to document improvements in ecological conditions over time as restoration and protection strategies are implemented.

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Table 1. Select water quality, physical habitat, land use and biological parameters measured at MBSS sites in the Liberty Reservoir watershed. Values indicating the presence of anthropogenic stress are outlined with a thick black line. Values highlighted in gray indicate good quality, rare, or unique stream resources. Appendix A shows the thresholds that were used to classify values as good quality or severely degraded. Appendix B includes maps that can be used to locate specific stream sites in watersheds

Parameter	**101-95**	**108-95**	**227-95**	**106-95**	**309-95**	**122-95**	**111-95**	**218-95**	**318-95**	**221-95**
Fish IBI Score	3.67	3.89	2.78	2.78	4.56		4.11	4.33	3.67	3.89
BIBI	3.89	3.67	2.11	4.11	3.67	3.67	3.89	3.67	2.78	4.33
NO3	1.49	2.47	6.28	9.07	4.69	3.01	3.49	3.47	4.60	4.04
D.O. (mg/L)	8.0	9.3	7.8	9.2	9.2	8.5	8.3	9.1	8.1	9.5
pH (units)	7.43	7.54	8.11	7.35	7.69	7.20	7.41	7.45	7.46	7.10
Sulfate	16.14	9.00	13.85	6.12	5.92	8.00	5.82	4.33	7.30	3.56
Temperature (Use Class)	22.2 (I)	21 (I)	23.6 (I)	13.6 (III)	20.8 (I)	14.5 (I)	20.2 (I)	18.8 (I)	22.2 (I)	16.2 (I)
Turbidity										
Instream Habitat Score	14	14	10	14	18	14	16	9	14	17
Epifaunal Substrate Score	8	16	12	17	15	14	17	11	15	18
Velocity/Depth Diversity	8	13	16	8	17	8	13	9	11	10
Pool Quality Score	11	12	11	8	18	8	14	8	16	11
Eroded Bank Area (m^2)										
Erosion Severity Score										
Bank Stability	5	8	10	8	8	5	8	9	7	12
Embeddedness	25	10	15	10	10	10	20	50	50	13
Buffer Width	50	50	10	40	0	15	6	0	0	10
Agricultural Land Use (%)	41.58	50.36	78.70	90.02	67.95	81.88	62.90	76.11	72.48	68.41
Urban Land Use (%)	1.23	4.93	15.50	0.00	5.31	10.62	0.24	0.84	2.06	0.19
Impervious Land Cover (%)	0.34	1.31	6.06	0.00	1.97	2.66	0.06	0.22	0.69	0.07

Parameter	113-95	211-95	226-95	225-95	212-95	104-95	124-95	121-95	323-95	323-96
Fish IBI Score	4.33	4.11	3.89	4.11	4.78	4.11	4.33	3.89	3.89	3.89
BIBI	4.33	3.44	3.89	3.22	3.44	3.67	3	3.22	2.56	4.11
NO3	2.76	4.88	4.84		5.66	8.14	6.94	6.06	4.81	4.92
D.O. (mg/L)	9.0	9.0	7.4	8.2	8.1	8.3	8.9	8.7	9.2	9.4
pH (units)	7.19	7.28	7.23		7.20	7.54	7.06	7.15	7.58	7.36
Sulfate	5.37	9.59	4.40		5.91	6.25	5.89	10.72	4.78	5.93
Temperature (Use Class)	14.8 (I)	20 (I)	24.2 (III)	20.3 (I)	19.3 (III)	17.5 (I)	15.3 (I)	20.1 (I)	17.4 (III)	17.6 (III)
Turbidity										
Instream Habitat Score	15	16	11	15	13	13	13	17	17	19
Epifaunal Substrate Score	17	15	11	12	13	15	11	18	17	15
Velocity/Depth Diversity	8	16	7	17	10	12	12	15	15	18
Pool Quality Score	10	15	8	15	16	12	11	16	14	18
Eroded Bank Area (m^2)										
Erosion Severity Score										
Bank Stability	8	11	13	7	6	5	11	7	10	15
Embeddedness	5	15	30	35	15	10	30	5	10	15
Buffer Width	50	3	10	50	30	40	0	0	50	6
Agricultural Land Use (%)	71.92	74.61	68.25	72.38	72.47	81.78	82.00	86.97	71.54	71.03
Urban Land Use (%)	0.22	0.59	3.51	0.69	11.86	0.00	2.90	2.84	4.78	4.52
Impervious Land Cover (%)	0.17	0.17	1.12	0.20	3.34	0.00	0.73	1.35	1.39	1.32

Parameter	208-96	209-96	309-96	118-96	302-96	311-96	127-96	305-96	224-96	320-96
Fish IBI Score	3.89	4.78	3.89	3.89		4.11	3.89		3.89	3.44
BIBI	1.67	2.78	3.44	3.89	2.56	2.78	2.33	3.67	2.11	4.33
NO3	2.58	4.05	4.38	4.91	4.76	4.45	4.76	5.84	5.74	5.44
D.O. (mg/L)	8.9	8.3	9.3	8.9		8.8	10.3		7.6	9.6
pH (units)	7.44	7.11	7.57	7.11	7.40	7.42	7.08	7.46	7.64	7.42
Sulfate	6.17	5.70	5.74	5.79	8.52	6.53	10.67	7.03	6.23	6.82
Temperature (Use Class)	19.9 (I)	19.7 (I)	16.9 (IV)	16.9 (I)		20.1 (III)	16.3 (I)		20.3 (III)	17.3 (I)
Turbidity										
Instream Habitat Score	17	16	16	19		17	12		16	9
Epifaunal Substrate Score	12	16	17	19		16	11		16	10
Velocity/Depth Diversity	14	15	20	11		18	13		18	17
Pool Quality Score	16	15	19	14		17	14		16	19
Eroded Bank Area (m^2)										
Erosion Severity Score										
Bank Stability	9	7	6	2		14	10		10	12
Embeddedness	60	20	30	15		35	15		10	45
Buffer Width	0	0	50	50		0	50		0	0
Agricultural Land Use (%)	67.60	83.17	77.05	71.64	73.15	69.32	73.09	73.69	78.48	73.90
Urban Land Use (%)	6.60	0.66	0.65	6.49	3.45	4.61	0.00	3.03	1.63	3.19
Impervious Land Cover (%)	1.80	0.18	0.18	1.71	1.25	1.32	0.00	1.12	0.57	1.18

Parameter	210-96	201-96	229-96	121-96	219-96	321-96	123-96	101C-00	102C-00	103C-00
Fish IBI Score	4.56	3.67	4.78	3.22	4.33	4.11		3.89	4.11	4.33
BIBI	2.56	3.22	2.56	3.00	3.00	2.11	1.67	5.00	4.11	4.33
NO3	5.62	6.40	6.50	4.44	5.83	4.02	9.01	1.05	1.13	1.05
D.O. (mg/L)	8.6	9.2	10.2	9.5	10.4	9.0	9.5	9.7	9.3	9.0
pH (units)	7.33	7.93	7.62	7.41	7.33	7.94	6.65	7.03	6.97	7.43
Sulfate	8.67	6.71	6.61	9.84	6.22	5.45	4.80	5.41	4.83	8.38
Temperature (Use Class)	20.7 (III)	17.4 (III)	20.2 (III)	16.6 (I)	18.2 (III)	19.2 (IV)	14.1 (I)	20.66 (III)	20.18 (III)	20.8 (III)
Turbidity								0.1	0.1	0.1
Instream Habitat Score	15	16	16	17	16	19	6	16	18	17
Epifaunal Substrate Score	10	18	15	18	17	18	6	19	18	17
Velocity/Depth Diversity	10	10	16	11	8	19	11	9	12	10
Pool Quality Score	15	12	15	13	12	19	12	10	15	10
Eroded Bank Area (m^2)								20	60	70
Erosion Severity Score								1	2	2
Bank Stability	5	8	13	7	14	17	15			
Embeddedness	65	15	30	10	50	10	80	12	12	20
Buffer Width	35	50	0	50	0	0	0	50	50	50
Agricultural Land Use (%)	72.77	83.03	83.89	77.02	81.56	68.88	90.78	22.38	22.93	25.70
Urban Land Use (%)	11.70	2.79	3.01	5.25	0.42	0.70	0.00	0.10	0.11	0.90
Impervious Land Cover (%)	3.34	0.99	1.07	1.42	0.19	0.19	0.00	0.01	0.01	0.22

Parameter	105C-00	204C-00	101-00	104-00	110-00	111-00	113-00	115-00	117-00	119-00
Fish IBI Score		3.89	4.11		4.11	3.89		4.11	3.00	4.33
BIBI	4.11	4.56	4.33	2.78	4.56	2.78	2.78	4.11	4.11	3.89
NO3	2.53	1.00	3.10	2.51	2.63	4.07	1.05	4.13	1.05	4.90
D.O. (mg/L)	9.1	9.7	8.6	7.2	8.4	8.1	7.8	9.4	7.8	8.5
pH (units)	6.86	7.39	7.09	7.10	6.82	7.05	7.11	7.28	6.85	7.14
Sulfate	6.80	7.92	5.21	24.19	2.76	3.53	5.87	5.32	7.57	4.14
Temperature (Use Class)	24.94 (I)	21.7 (III)	22.03 (I)		21.91 (I)	23.65 (I)		21.04 (I)	24.09 (I)	27.18 (I)
Turbidity	0.3	0.1	2.3	4.3	4.2	13.4	2.3	1.8	2.3	3.9
Instream Habitat Score	17	18	15	9	13	15	16	18	15	18
Epifaunal Substrate Score	18	18	17	10	14	17	15	18	17	18
Velocity/Depth Diversity	14	15	8	10	7	11	8	12	8	10
Pool Quality Score	14	13	10	15	8	10	8	8	8	10
Eroded Bank Area (m^2)	50	40	26	0	50	55	25	0	23	35
Erosion Severity Score	2.5	2.0	2.0	0.0	1.5	3.0	2.0	0.0	2.0	2.0
Bank Stability										
Embeddedness	25	25	15	13	30	20	15	7	15	15
Buffer Width	50	50	0	0	15	20	50	1	50	4
Agricultural Land Use (%)	73.05	25.00	59.33	83.12	60.36	95.31	32.37	70.26	28.00	87.50
Urban Land Use (%)	10.88	0.55	5.64	11.69	0.00	0.07	0.11	6.21	0.29	0.86
Impervious Land Cover (%)	3.15	0.13	1.77	5.41	0.00	0.02	0.08	1.66	0.12	0.26

Parameter	202-00	203-00	207-00	209-00	212-00	216-00	303-00	318-00
Fish IBI Score	4.11	4.11	3.67	4.11	3.89	3.89	4.33	4.11
BIBI	4.11	3.44	3.44	3.44	3.00	3.89	3.44	3.44
NO3	4.92	3.75	5.79	2.86	1.86	4.45	2.98	3.56
D.O. (mg/L)	8.1	9.1	8.5	9.0	8.8	8.4	8.1	8.8
pH (units)	7.97	7.41	6.82	7.20	7.32	7.49	7.41	7.47
Sulfate	5.95	5.83	14.54	6.10	8.98	5.74	6.01	5.62
Temperature (Use Class)	23.61 (I)			23.82 (I)	20.22 (III)	21.43 (I)	24.61 (I)	23.79 (I)
Turbidity	4.3	6.7	3.5	2.2	1.7	9.5	7.8	6.3
Instream Habitat Score	18	15	14	15	19	18	17	17
Epifaunal Substrate Score	18	16	16	17	17	17	17	16
Velocity/Depth Diversity	18	9	12	11	16	10	17	17
Pool Quality Score	18	10	9	12	15	8	16	18
Eroded Bank Area (m^2)	32	12	35	36	35	46	60	91
Erosion Severity Score	1.5	0.5	2.0	2.0	2.0	2.0	1.0	2.5
Embeddedness	17	34	20	22	20	9	30	39
Buffer Width	15	50	40	25	50	0	50	50
Agricultural Land Use (%)	79.42	76.98	79.85	64.16	50.00	74.38	69.01	75.03
Urban Land Use (%)	1.73	0.62	10.47	0.09	8.77	2.55	0.70	0.71
Impervious Land Cover (%)	0.61	0.17	4.92	0.03	2.45	0.75	0.19	0.19

Table 2. Select water quality, physical habitat, land use and biological parameters measured at MBSS sites in the Prettyboy Reservoir watershed. Values indicating the presence of anthropogenic stress are outlined with a thick black line. Values highlighted in gray indicate good quality stream resources. Appendix A shows thresholds to used to classify values as good quality or stressed. Appendix B includes maps that can be used to locate specific stream sites in watersheds.

Parameter	**114-96**	**211-96**	**307-96**	**315-96**	**207-96**	**316-96**	**314-96**	**306-96**	**112-96**
Fish IBI Score		4.11	3.89	3.89	3.44	4.33	4.33	4.11	
BIBI	1.67	3.44	3.44	3.44	3.22	3.44	3.22	3.44	3
NO3	4.82	5.25	2.96	2.91	6.81	3.01	3.22	3.3	5.06
D.O. (mg/L)	10.2	9.9	9.8	9.7	9.8	11.1	9.6	9.7	10.6
pH (units)	7.09	7.76	8.35	8.61	7.17	8.9	7.61	8.06	6.96
Sulfate	14.03	5.64	5.52	5.64	9.2	5.92	5.91	5.98	2.65
Temperature (Use Class)	18.4 (III)	17.1 (III)	17.2 (III)	19.7 (III)	19.2 (III)	12.9 (III)	22.8 (III)	18 (III)	13.9 (III)
Turbidity									
Instream Habitat Score	10	16	19	17	10	17	13	14	13
Epifaunal Substrate Score	11	14	17	15	9	19	13	13	10
Velocity/Depth Diversity	6	16	17	17	8	15	13	16	10
Pool Quality Score	9	15	16	15	7	15	11	13	7
Eroded Bank Area (m^2)									
Erosion Severity Score									
Bank Stability	3	9	19	18	3	15	7	15	14
Embeddedness	60	70	30	30	70	25	60	65	10
Buffer Width	10	30	50	50	0	20	50	0	1
Agricultural Land Use (%)	91.11	88.91	65.95	65.88	91.92	69.21	68.88	70.96	82.83
Urban Land Use (%)	0	2.39	0.39	0.39	0	0.45	0.57	0.51	0
Impervious Land Cover (%)	0	0.65	0.11	0.11	0	0.13	0.17	0.15	0

Parameter	101-00	102-00	104-00	108-00	109-00	110-00	111-00	112-00	113-00	214-00
Fish IBI Score	1.44	2.11	3.89	3.67	4.11	4.56	3.67		4.11	5.00
BIBI	3.67	4.56	4.33	4.56	2.78	3.67	4.33	4.33	3.44	3.89
NO3	5.71	4.67	2.45	2.90	6.39	5.23	3.98	5.00	3.44	5.68
D.O. (mg/L)	9.0	8.4	9.1	9.5	8.9	9.3	9.1	8.4	8.1	9.9
pH (units)	7.17	7.04	7.05	7.10	7.26	7.20	6.90	6.82	7.31	7.22
Sulfate	5.90	6.22	3.87	6.53	7.44	9.33	3.75	5.82	6.60	10.22
Temperature (Use Class)	20.42 (III)	20.02 (III)	20.44 (III)	20.38 (III)	24.9 (III)	21.93 (III)		20.83 (III)	23.04 (III)	23.76 (III)
Turbidity	7.4	6.1	6.7	3.5	4.9	3.8	5.4	3.1	10.5	4.4
Instream Habitat Score	11	7	16	17	16	15	13	8	14	14
Epifaunal Substrate Score	11	6	15	16	16	16	14	8	14	15
Velocity/Depth Diversity	8	8	10	7	16	10	9	7	17	15
Pool Quality Score	7	8	10	6	17	7	8	7	14	17
Eroded Bank Area (m^2)	30	116	80	70	100	67	24	76	140	35
Erosion Severity Score	1	2.5	1.5	1.5	2	1.5	1	2.5	1.5	2.5
Bank Stability										
Embeddedness	20	55	25	10	20	15	25	60	30	35
Buffer Width	0	0	50	50	21	50	0	8	0	0
Agricultural Land Use (%)	53.88	76.33	66.65	68.80	84.43	85.83	73.90	77.94	75.87	87.63
Urban Land Use (%)	0.40	0.00	0.00	0.00	3.47	0.31	0.00	0.00	0.33	0.14
Impervious Land Cover (%)	0.10	0.00	0.00	0.00	1.11	0.10	0.00	0.00	0.13	0.05

Table 3. Select water quality, physical habitat, land use and biological parameters measured at MBSS sites in the Mattawoman Creek watershed. Values indicating the presence of anthropogenic stress are outlined with a thick black line. Values highlighted in gray indicate good quality, rare, or unique stream resources. Appendix A shows thresholds used to classify values as good quality or severely degraded. Appendix B includes maps that can be used to locate specific stream sites in watersheds.

Parameter	**314-95**	**222-95**	**211-95**	**221-95**	**220-95**	**209-95**	**115-99**	**111-99**	**103-99**	**205-99**	**105-99**
Fish IBI Score	3.50	1.00	4.50	4.00		2.25		3.08	3.00	2.75	2.50
BIBI	2.71	2.43	4.43	3.86	1.57	2.43	3.57	2.71	3.00	2.71	3.29
NO3	0.24	0.13	0.56	0.44	0.19	0.4	0.22	0.31	0.64	0.52	0.58
D.O. (mg/L)	7.1	1.8	3.1	6.1		3.2	7.5	7.3	3.2	6.7	7.0
pH (units)	6.60	5.94	6.61	5.90	4.94	6.29	7.60	7.06	6.18	6.20	6.82
Sulfate	12.84	11.74	12.85	13.03	14.72	13.70	12.98	9.98	14.12	14.28	9.69
Temperature (Use Class)	19.4 (I)	18.9 (I)	26.3 (I)	21.5 (I)		18.6 (I)	18.5 (I)	21.7 (I)	20.3 (I)	18.5 (I)	23.4 (I)
Turbidity											
Instream Habitat Score	15	7	8	15		6	8	11	16	14	11
Epifaunal Substrate Score	14	3	6	13		5	10	12	16	13	15
Velocity/Depth Diversity	17	1	7	14		11	9	11	14	9	10
Pool Quality Score	15	2	12	16		14	8	15	18	17	13
Eroded Bank Area (m^2)											
Erosion Severity Score											
Bank Stability	7	15	8	6		14	14	9	11	7	7
Embeddedness	40	100	80	25		60	25	20	38	30	16
Buffer Width	10	50	6	50		17	2	50	35	26	0
Agricultural Land Use (%)	17.74	18.56	15.10	13.68	19.81	20.12	7.23	6.62	27.67	19.12	19.82
Urban Land Use (%)	9.53	10.57	9.06	8.80	11.36	11.71	55.66	31.96	7.91	12.35	45.74
Impervious Land Cover (%)	3.02	3.45	2.30	2.22	3.72	3.75	12.37	8.50	1.64	3.10	13.97

Parameter	110-99	104-99	101-99	106-99	202-99	114-99	113-99	209-99	108-99	207-99	112-99
Fish IBI Score	2.86	5.00	3.00	1.00	2.75	2.14	4.75	1.00	4.25	2.31	4.75
BIBI	2.71	2.14	1.29	1.86	2.14	4.43	4.43	3.57	2.71	3.00	4.14
NO3	0.19	0.00	0.00	0.00	0.40	0.30	0.66	0.62	0.72	0.37	1.00
D.O. (mg/L)	4.3	4.5	4.4	3.5	4.0	7.0	7.9	7.2	7.6	4.5	8.0
pH (units)	6.26	6.48	5.62	4.88	5.24	7.16	6.33	5.99	6.53	6.68	6.24
Sulfate	6.31	5.61	17.25	10.62	11.26	4.51	15.62	11.58	13.40	10.67	11.26
Temperature (Use Class)	20.6 (I)	21.8 (I)	17.7 (I)	19.3 (I)	17.7 (I)	21.1 (I)	17.2 (I)	19.1 (I)	20.2 (I)	18.9 (I)	17.7 (I)
Turbidity											
Instream Habitat Score	13	15	13	6	17	11	8	6	14	9	16
Epifaunal Substrate Score	15	15	17	6	14	14	6	6	14	11	16
Velocity/Depth Diversity	13	10	7	5	11	8	8	8	13	10	15
Pool Quality Score	15	15	11	10	17	11	16	14	16	11	17
Eroded Bank Area (m^2)											
Erosion Severity Score											
Bank Stability	17	17	17	11	17	10	14	11	12	13	11
Embeddedness	10	100	100	20	30	14	100	25	25	30	10
Buffer Width	50	50	10	0	30	0	0	50	0	10	50
Agricultural Land Use (%)	3.97	5.53	7.74	22.51	13.44	25.62	7.57	8.14	10.28	12.66	21.09
Urban Land Use (%)	12.09	1.38	5.94	1.63	3.54	1.65	2.72	3.92	18.86	11.72	15.47
Impervious Land Cover (%)	3.00	0.26	1.21	0.41	0.79	0.4	0.66	0.97	4.29	2.94	3.77

Parameter	303-99	206-99	301-99	203-99	204-99	104-00	105-00	108-00	109-00	115-00	117-00
Fish IBI Score	2.25	1.00	1.25	2.00	1.11	2.00	1.75	2.00	2.75		
BIBI	3.29	1.57	1.29	3.29	2.14	3.57	3.00	2.71	1.86	2.14	3.29
NO3	0.54	0.61	2.69	0.10	0.11	0.05	0.16	0.17	0.33	0.28	0.10
D.O. (mg/L)	0.0	3.4	2.5	6.0	7.3	6.8	7.3	7.1	6.7	5.3	6.9
pH (units)	5.68	5.70	6.03	6.31	6.42	6.61	5.40	5.99	7.05	6.38	5.66
Sulfate	13.82	15.48	33.80	18.42	19.64	11.73	7.85	9.27	9.68	7.57	3.22
Temperature (Use Class)	24.7 (I)	21.4 (I)	20.6 (I)	18.9 (I)	19.7 (I)	22.1 (I)	24.1 (I)	24.1 (I)	26.09 (I)	28.4 (I)	22.64 (I)
Turbidity						3.3	9.3	8.3	18.9	15.4	11.7
Instream Habitat Score	16	4	3	16	16	11	18	19	13	19	8
Epifaunal Substrate Score	15	4	5	15	15	9	17	17	16	13	6
Velocity/Depth Diversity	9	1	1	15	15	6	15	17	14	6	7
Pool Quality Score	18	5	6	17	17	8	19	17	11	19	6
Eroded Bank Area (m^2)						25	10	5	10	0	25
Erosion Severity Score						1	1	0.5	0.5	0	0.5
Bank Stability	15	14	13	10	8						
Embeddedness	60	40	19	10	10	85	30	35	40	45	85
Buffer Width	30	50	50	14	2	16	50	5	50	10	20
Agricultural Land Use (%)	15.84	18.33	17.49	20.03	21.47	17.67	13.86	21.46	5.93	9.00	0.00
Urban Land Use (%)	8.75	10.65	9.94	12.87	11.64	6.27	0.64	0.50	38.38	45.13	0.00
Impervious Land Cover (%)	2.17	2.66	2.48	3.39	3.06	1.63	0.16	0.14	13.65	19.00	0.00

Parameter	210-00	212-00	216-00	320-00	033S-00
Fish IBI Score	3.50	4.25	4.43	3.57	3.50
BIBI	4.14	4.71	4.43	3.57	3.86
NO3	0.26	0.19	0.27	0.08	0.14
D.O. (mg/L)	7.0	6.6	7.0	6.9	8.6
pH (units)	6.58	7.03	6.35	6.60	6.73
Sulfate	11.24	8.86	11.01	8.22	9.47
Temperature (Use Class)	28.01 (I)	26.5 (I)	28.01 (I)	30.46 (I)	26.07 (I)
Turbidity	8.9	8.5	8.6	7.9	5.6
Instream Habitat Score	17	16	17	18	19
Epifaunal Substrate Score	10	13	12	15	18
Velocity/Depth Diversity	13	11	15	13	17
Pool Quality Score	16	16	18	15	12
Eroded Bank Area (m^2)	100	20	35	35	7
Erosion Severity Score	1	1.5	2	1	2
Bank Stability					
Embeddedness	15	40	20	50	35
Buffer Width	50	50	32	50	50
Agricultural Land Use (%)	11.68	25.84	10.48	20.07	17.63
Urban Land Use (%)	17.59	1.40	18.72	10.38	9.49
Impervious Land Cover (%)	5.55	0.37	5.93	3.37	3.02

Table 4. Stressors to fish species that were expected to occur but were absent at MBSS sites in the Liberty Reservoir watershed where stressors were identified.

Site	Species	Parameters
101-95	Brook Trout	temperature
227-95	River Chub	impervious
218-95	Brook Trout	canopy shading
226-95	Brook Trout	impervious, temperature
104-95	Creek Chub Rosyside Dace White Sucker	nitrate nitrate nitrate
121-95	Brook Trout Cutlips Minnow Margined Madtom River Chub	impervious land cover, agriculture landuse, nitrate agriculture land use agriculture land use embeddedness
323-95	Brook Trout	impervious land cover
323-96	Brook Trout	impervious land cover
118-96	Brook Trout	impervious, bank erosion
210-96	Brook Trout	nitrate, impervious land cover,
121-96	Brook Trout	impervious land cover
123-96	Brook Trout	agriculture land use, nitrate, embeddedness
111-00	Brook Trout	agriculture land use
119-00	Brook Trout	agriculture land use
207-00	Brook Trout	agriculture land use, impervious land cover, nitrate

Table 5. Stressors to fish species that were expected to occur but were absent at MBSS sites in the Prettyboy Reservoir watershed where stressors were identified.

Site	Species	Parameters
101-00	Brook Trout	nitrate
108-00	Brook Trout	nitrate
109-00	Brook Trout	nitrate
110-00	Brook Trout	nitrate
214-00	Brook Trout	nitrate, agriculture land use
	Margined Madtom	agriculture land use
	Swallowtail Shiner	agriculture land use
	Cutlips Minnow	agriculture land use

Table 6. Stressors to fish species that were expected to occur but were absent at MBSS sites in the Mattawoman Creek watershed where stressors were identified.

Site	Species	Parameters
222-95	Redbreast Sunfish	acidity, poor pool habitat
	American Eel	poor pool habitat
	Bluespotted Sunfish	poor pool habitat
	Margined Madtom	poor pool habitat, low dissolved oxygen
	Pumpkinseed	poor pool habitat
221-95	Redbreast Sunfish	acidity
103-99	Fallfish	insuficient depth
	Redbreast Sunfish	insuficient depth
	Swallowtail Shiner	insuficient depth, low dissolved oxygen
202-99	Blacknose dace	acidity
	Fallfish	acidity
	Tadpole Madtom	acidity
105-99	Fallfish	impervious land cover
	Least Brook Lamprey	impervious land cover
	Pirate Perch	impervious land cover
	Tadpole Madtom	impervious land cover
206-99	Creek Chubsucker	acidity
	Pumpkinseed	acidity
110-99	Sea Lamprey	acidity

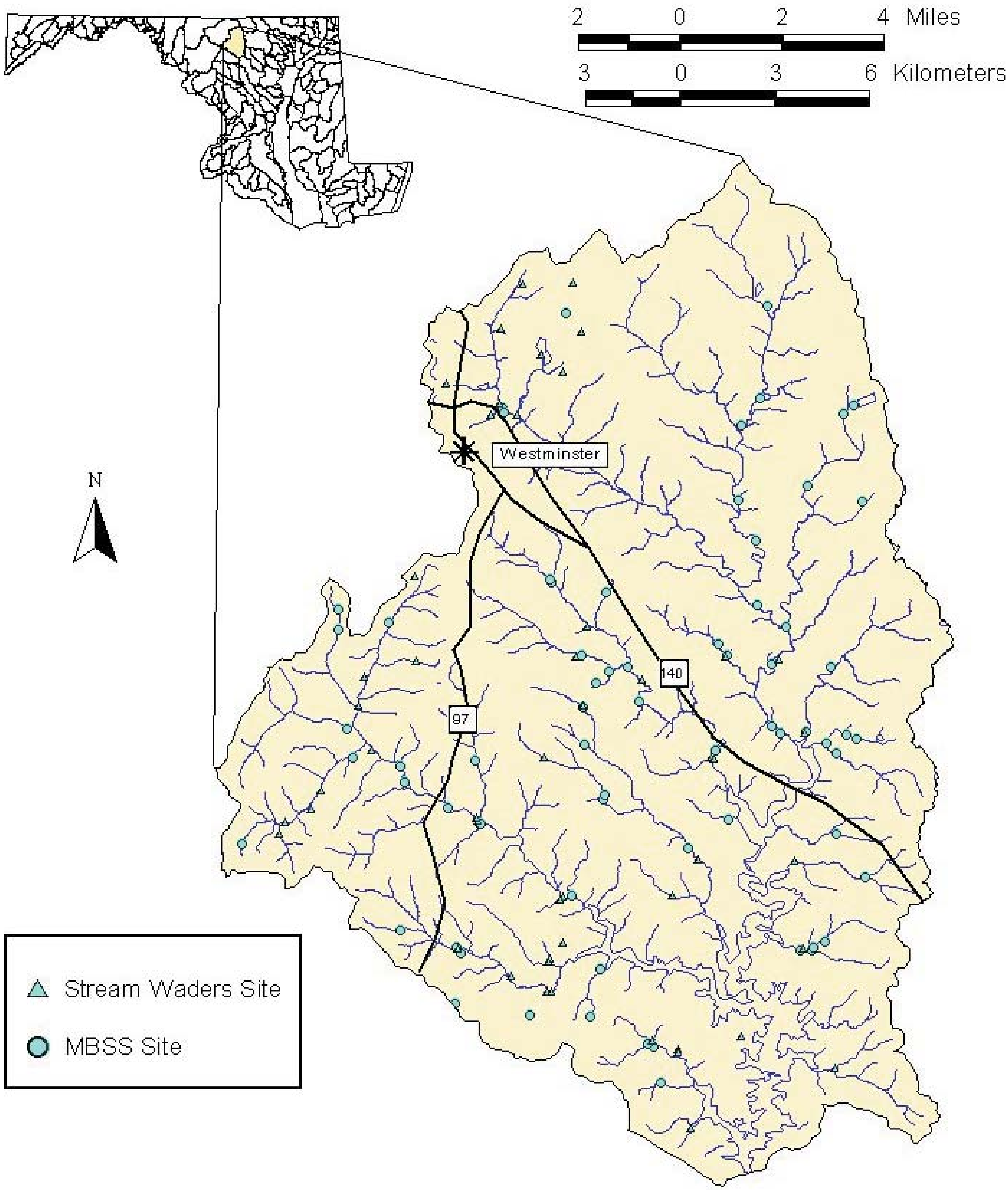


Figure 1. Sites sampled in Liberty Reservoir Watershed from 1995 to 2000.

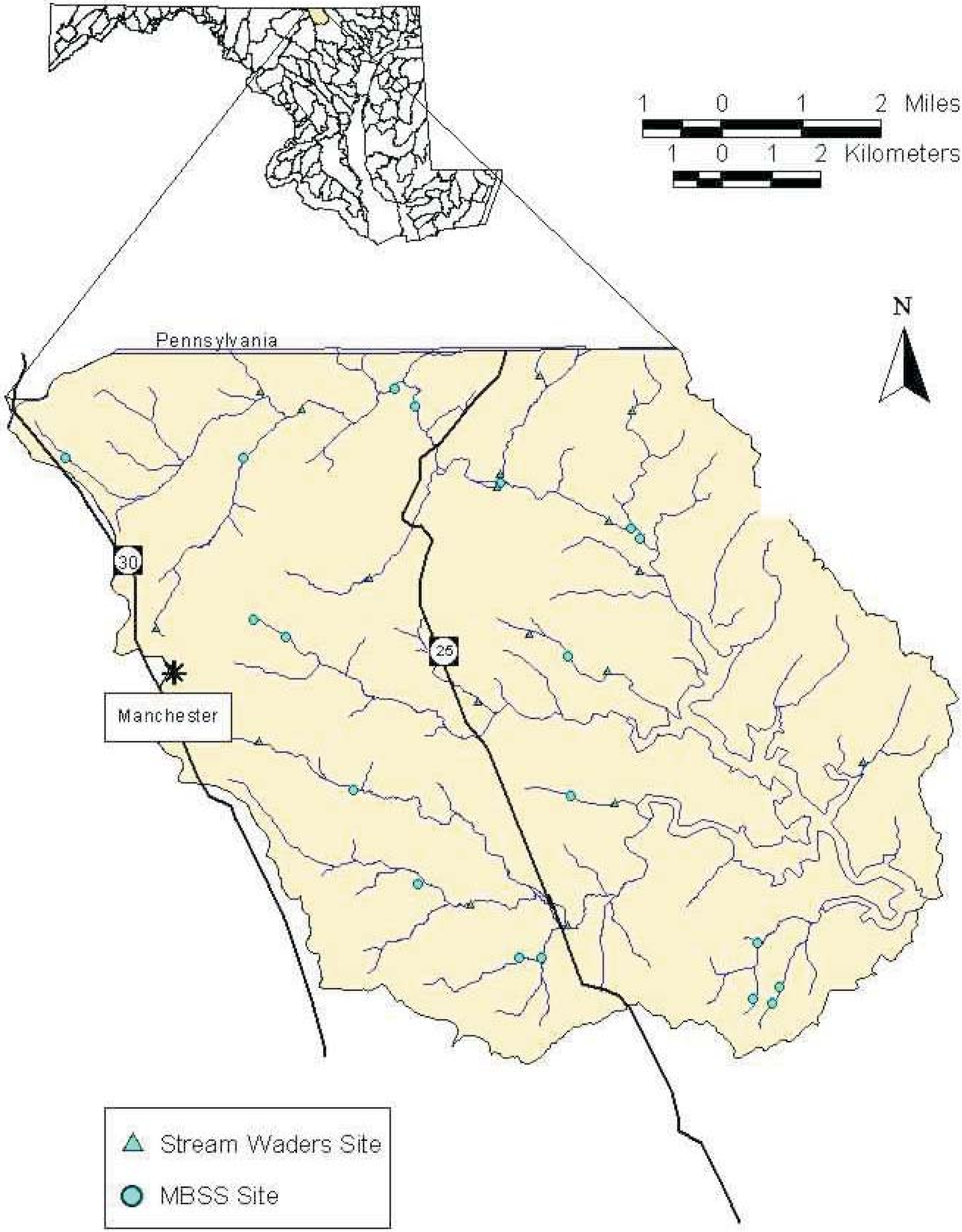


Figure 2. Sites sampled in Prettyboy Reservoir Watershed from 1996 to 2000.

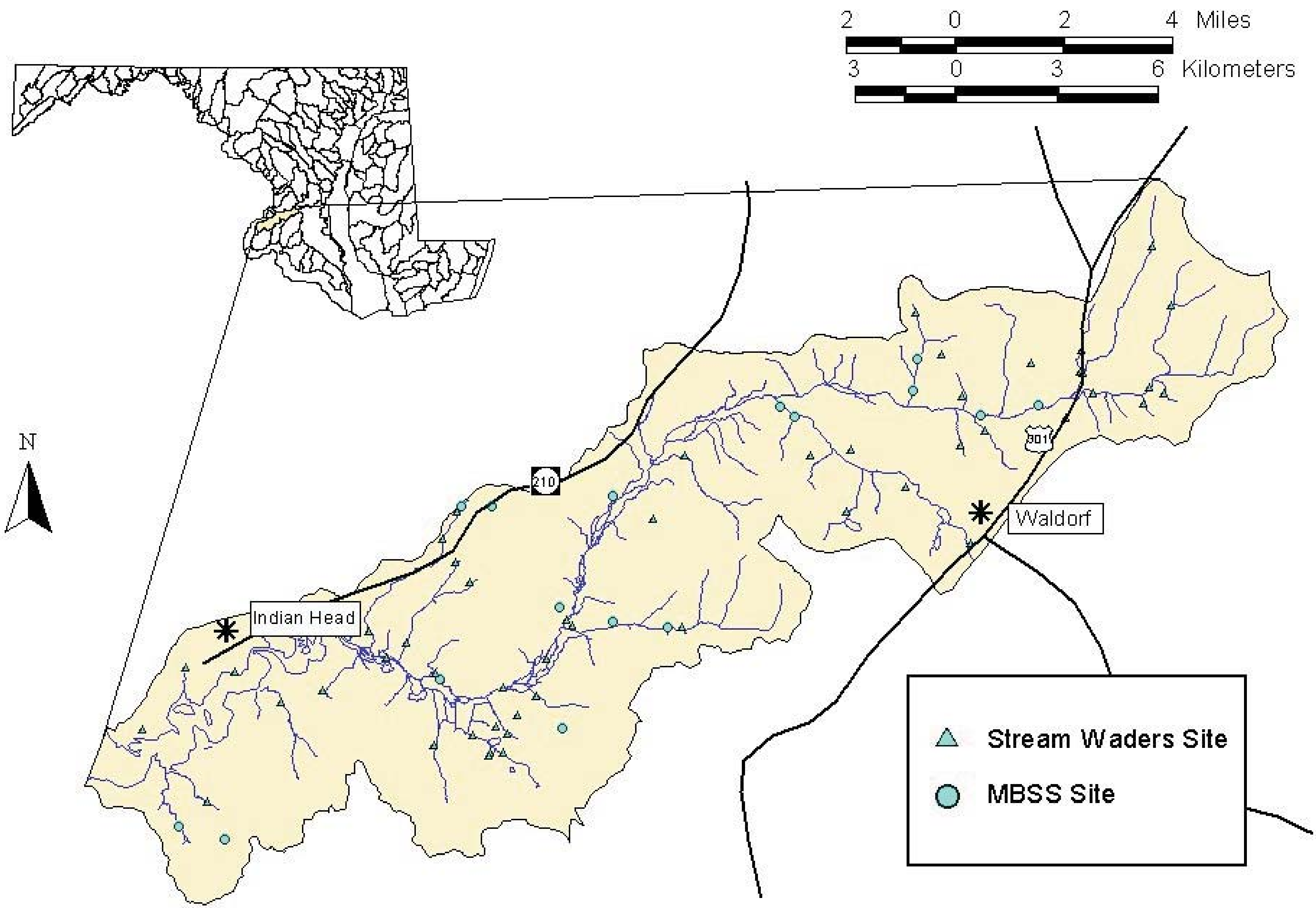


Figure 3. Sites sampled in Mattawoman Creek Watershed from 1995 to 2000.

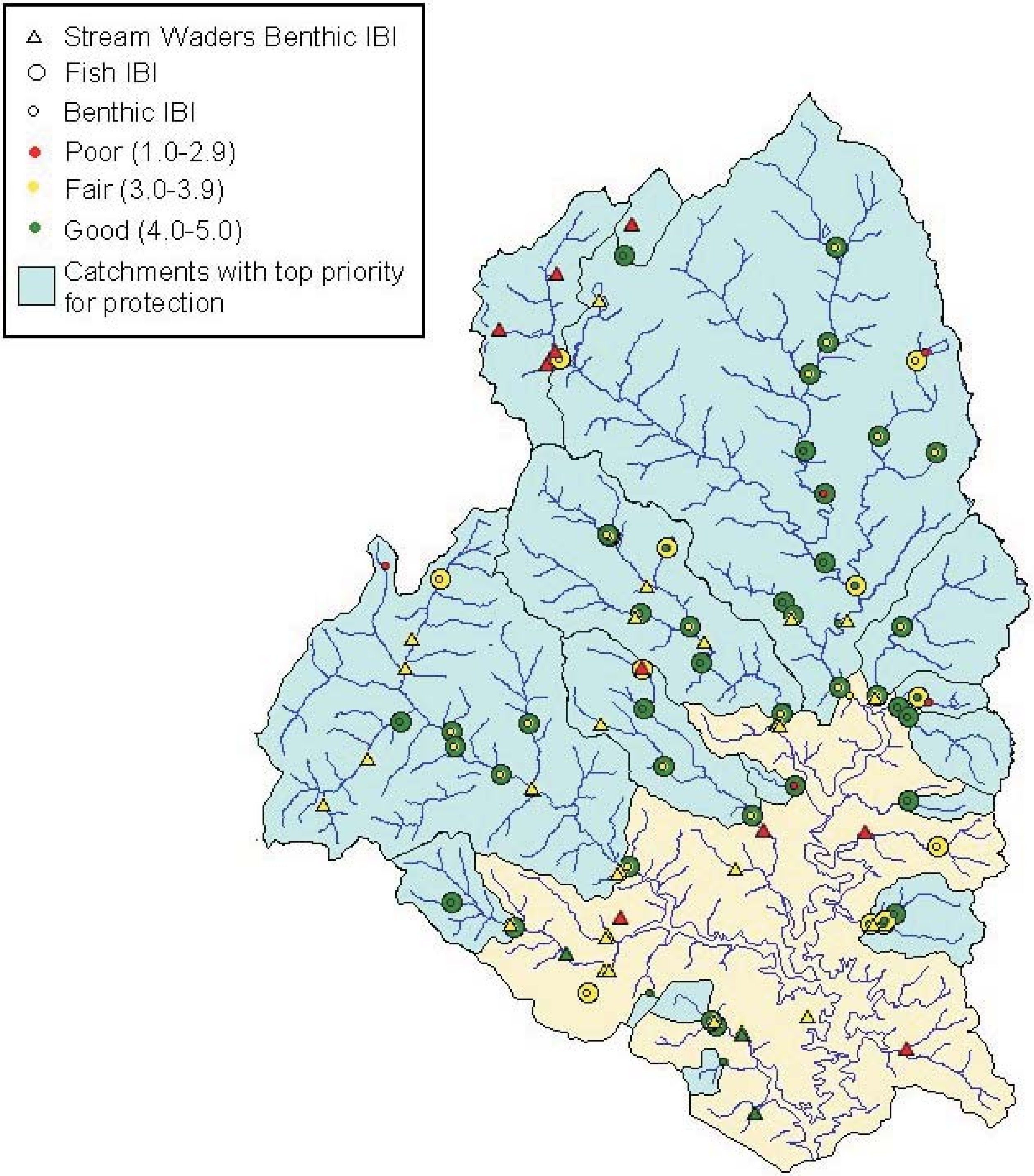


Figure 4. Areas in Liberty Reservoir Watershed recommended for protection.

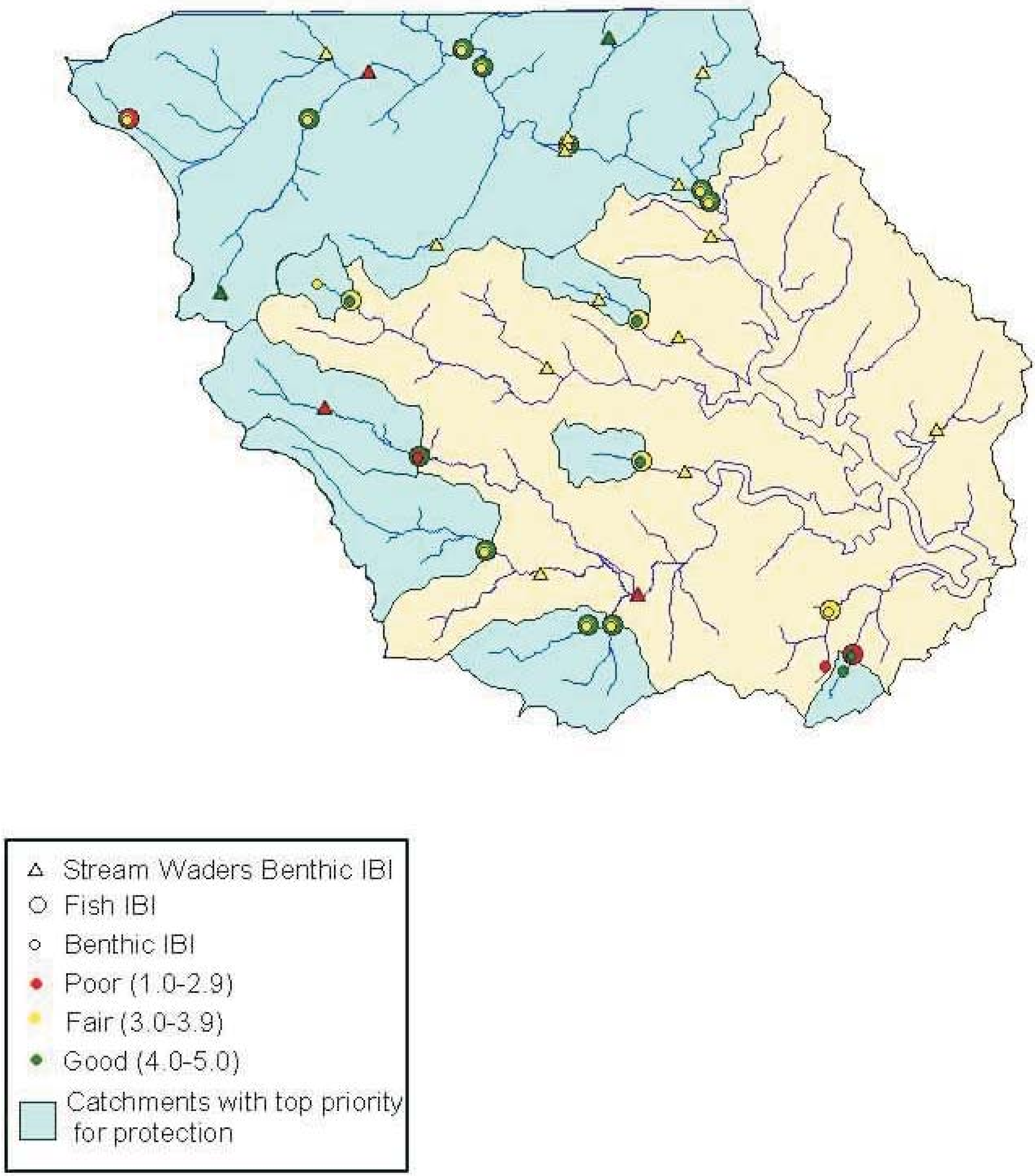


Figure 5. Areas in Prettyboy Reservoir Watershed recommended for protection.

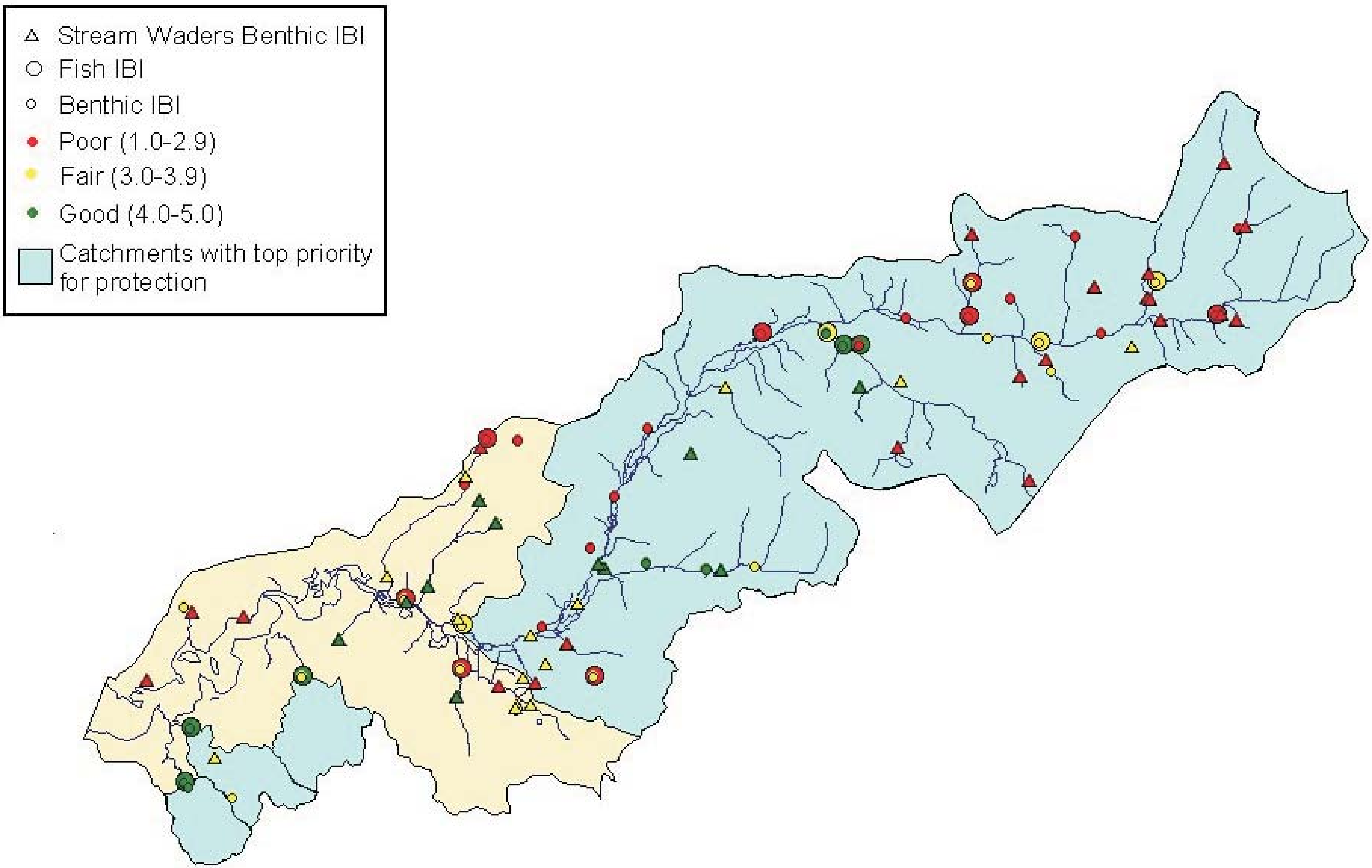


Figure 6. Areas in Mattawoman Creek Watershed recommended for protection.

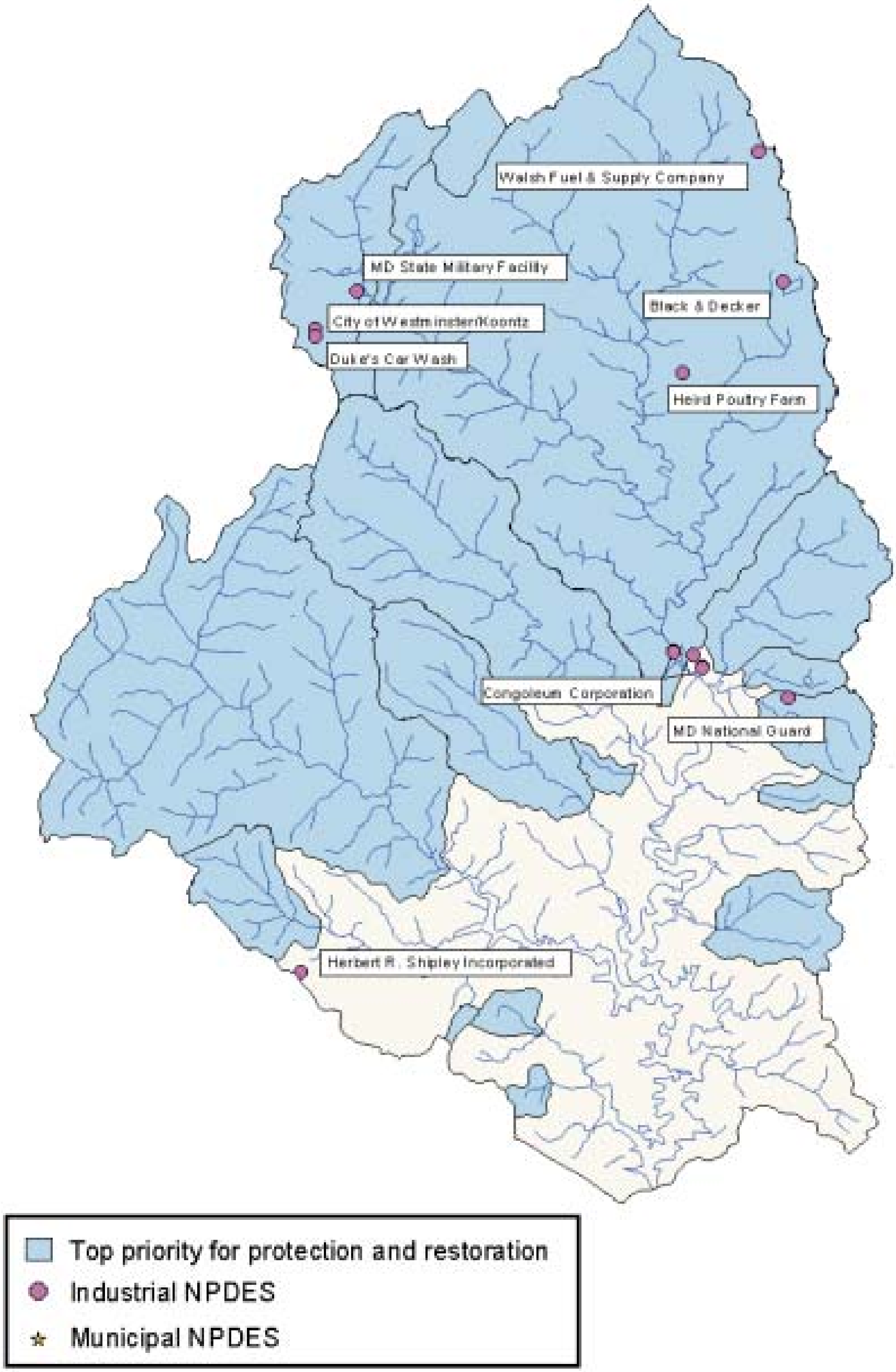


Figure 7. Municipal and Industrial NPDES sites in the Liberty Reservoir Watershed

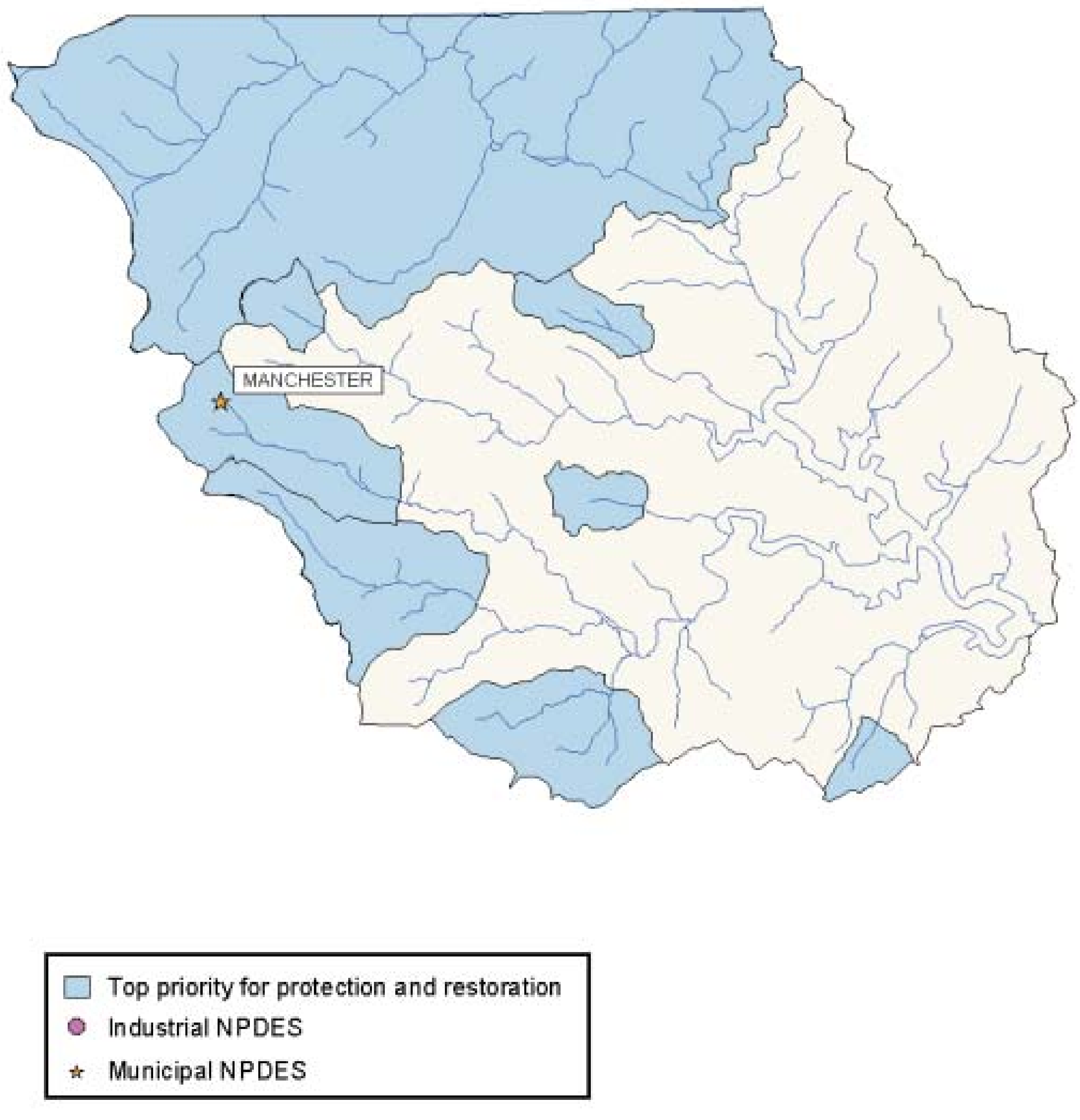


Figure 8. Municipal and Industrial NPDES sites in the Prettyboy Reservoir Watershed

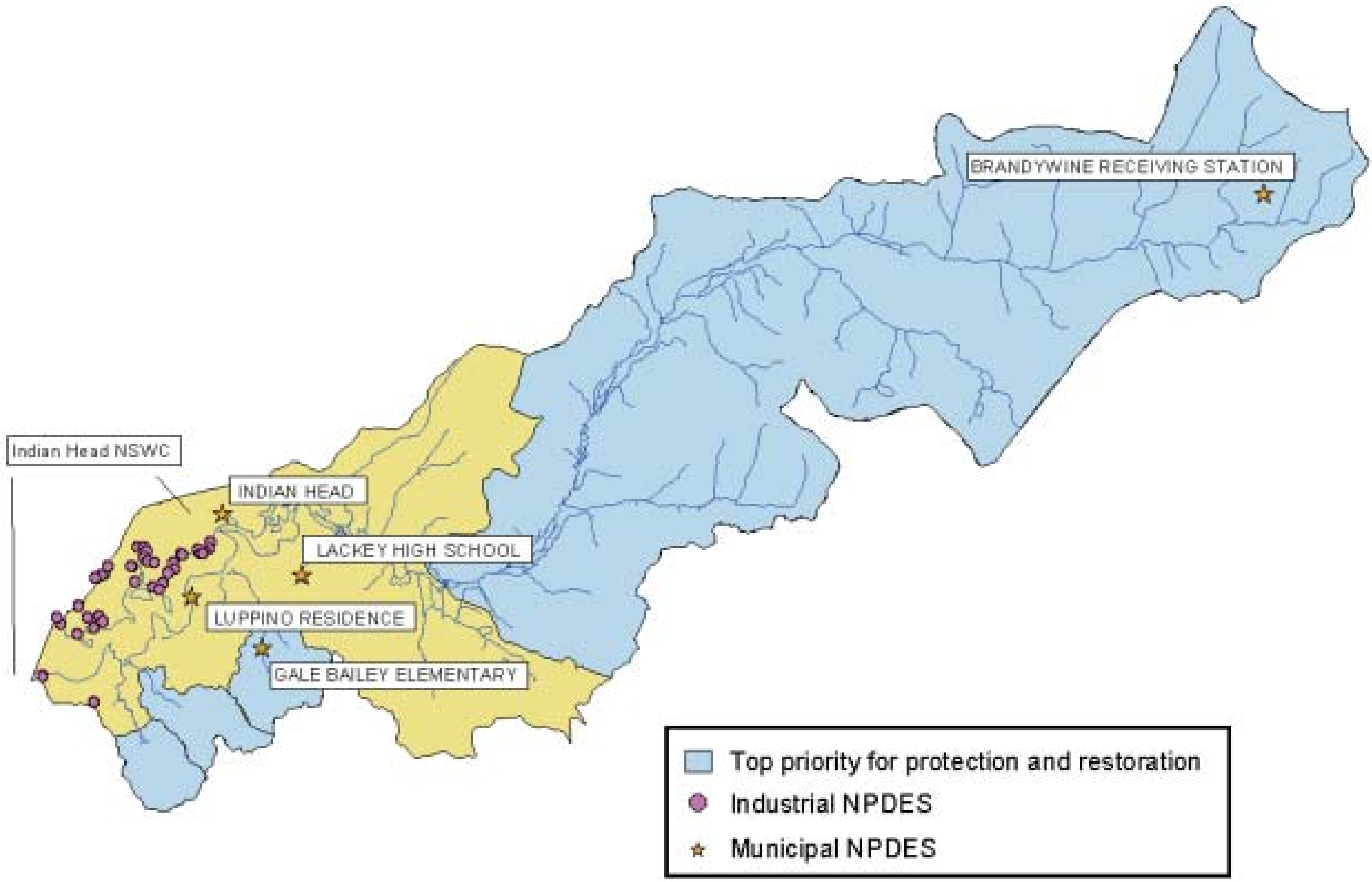


Figure 9. Municipal and Industrial NPDES sites in the Mattawoman Creek Watershed

Appendix A: Thresholds for classifying physical habitat, chemical, biological, and land use values as indicative of degradation or good quality, rare, or unique stream resources.

Biological Parameters

Fish IBI Score: Fish Index of Biotic Integrity, scored on the following scale:

Good	IBI Score 4.0-5.0	Comparable to reference streams considered to be minimally impacted. Fall within the upper 50% of reference site conditions.
Fair	IBI Score 3.0-3.9	Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of these minimally-impacted streams. Fall within the lower portion of the range of reference sites (10^{th} to 50^{th} percentile).
Poor	IBI Score 2.0-2.9	Significant deviation from reference conditions, with many aspects of biological integrity not resembling the qualities of these minimally-impacted streams, indicating some degradation.
Very Poor	IBI Score 1.0-1.9	Strong deviation from reference conditions, with most aspects of biological integrity not resembling the qualities of these minimally-impacted streams, indicating severe degradation.

Site is shaded if FIBI score is <3.0.
Site is outlined in bold if FIBI score is >4.0.

Benthic IBI Score: Benthic Index of Biotic Integrity, scored on the following scale:

Good	IBI Score 4.0-5.0	Comparable to reference streams considered to be minimally impacted. Fall within the upper 50% of reference site conditions.
Fair	IBI Score 3.0-3.9	Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of these minimally-impacted streams. Fall within the lower portion of the range of reference sites (10^{th} to 50^{th} percentile).
Poor	IBI Score 2.0-2.9	Significant deviation from reference conditions, with many aspects of biological integrity not resembling the qualities of these minimally-impacted streams, indicating some degradation.
Very Poor	IBI Score 1.0-1.9	Strong deviation from reference conditions, with most aspects of biological integrity not resembling the qualities of these minimally-impacted streams, indicating severe degradation.

Site is shaded if BIBI score is <3.0.
Site is outlined in bold if BIBI score is >4.0.

Water Quality Parameters

NO_3 Nitrate Nitrogen (mg/L): Site is shaded if value is >10 mg/L, and outlined in bold if value is < 1.0 mg/L.

D.O. Dissolved Oxygen (mg/L): Site is shaded if value is ≤ 5 mg/L water criterion (COMAR 26.08.02).

pH (units): Site is shaded if value is ≤ 5.0. pH less than 5.0 is considered harmful to stream biota, especially fish (COMAR 26.08.02).

SO_4 Sulfate (mg/L): Site is shaded if value is ≥ 50 mg/L.

Temperature (°C): Site is shaded if value exceeds the temperature criteria for Use Class I waters (32°C). All streams in the watersheds discussed in this report are Use Class I.

Turbidity (NTUs): Site is shaded if value is ≥ 10 NTUs.

Physical Habitat Parameters:

Physical habitat variables include the following:

Instream Habitat: Scored based on the value of instream habitat available to the fish community.

Epifaunal Substrate: Scored based on the amount and variety of hard, stable substrates used by benthic macroinvertebrates.

Velocity/Depth Diversity: Scored based on the variety of velocity/depth regimes present at a site.

Pool/Glide/Eddy Quality: Scored based on the variety and complexity of slow or still water habitat present at a site.

Bank Stability: Scored based on the stability of stream banks and potential for erosion at a site.

Site is shaded if a score for any physical habitat variable is ≤ 6, and outlined in bold if the score is > 16.

Eroded Bank Area (m^2): Site is shaded if value is > 75 meters. Site is and outlined in bold if value = 0 meters.

Erosion Severity Score: Severity of erosion on both stream banks. Site is shaded if value is ≥ 2.5, and outlined in bold if value is 0.

Embeddedness: Site is shaded in if value is 100 percent and outlined in bold if value is 0 percent.

Land Use Parameters

Riparian Buffer Width: Site is shaded if buffer width is <10 meters and outlined in bold if width is ≥ 50 meters.

Agricultural Land Use: Site is shaded if value is ≥ 75 percent.

Urban Land Use (%): Site is shaded if value is > 50 percent and outlined in bold if value is ≤ 20 percent.

Impervious Land Cover: Site is shaded if value is > 10 percent, and outlined in bold if value is < 2 percent.

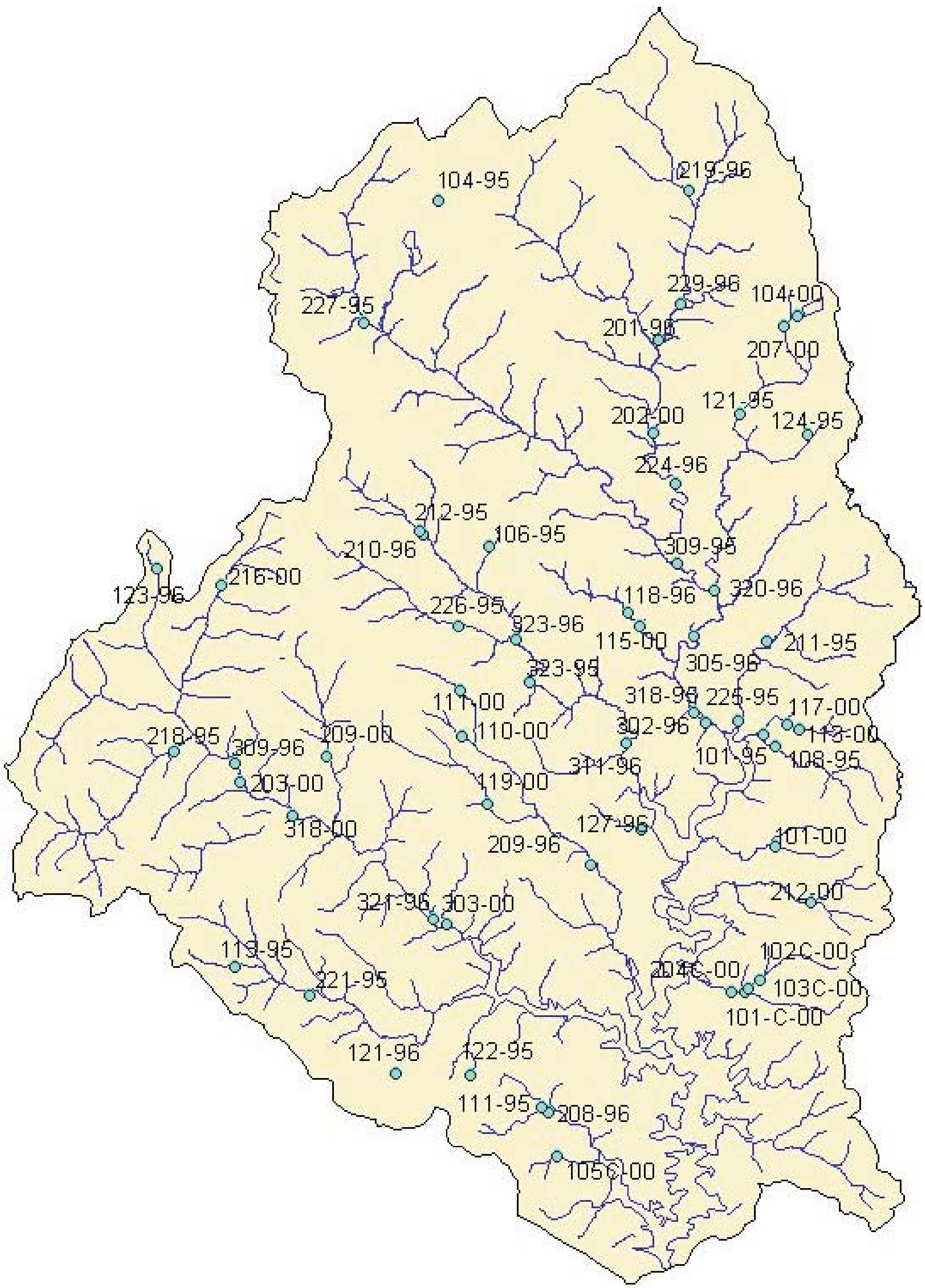
Appendix B. List of stream names and locations for MBSS sites by watershed.

Site	Stream Name	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
Liberty Reservoir Watershed			
101-95	UNNAMED TRIBUTARY TO NORTH BRANCH PATAPSCO RIVER	39.4943	76.8628
108-95	UNNAMED TRIBUTARY TO NORTH BRANCH PATAPSCO RIVER	39.4915	76.8593
227-95	WEST BRANCH PATAPSCO RIVER	39.5849	76.9761
106-95	UNNAMED TRIBUTARY TO BEAVER RUN	39.5357	76.9406
309-95	NORTH BRANCH OF PATAPSCO RIVER	39.5320	76.8871
122-95	UNNAMED TRIBUTARY TO MORGAN RUN	39.4197	76.9458
111-95	UNNAMED TRIBUTARY TO LIBERTY RESERVOIR	39.4124	76.9257
218-95	UNNAMED TRIBUTARY TO MORGAN RUN	39.4905	77.0298
318-95	NORTH BRANCH PATAPSCO RIVER	39.4991	76.8822
221-95	LITTLE MORGAN RUN	39.4371	76.9914
113-95	UNNAMED TRIBUTARY TO LITTLE MORGAN RUN	39.4434	77.0128
211-95	UNNAMED TRIBUTARY TO NORTH BRANCH PATAPSCO RIVER	39.5150	76.8614
226-95	MIDDLE RUN	39.5184	76.9489
225-95	UNNAMED TRIBUTARY TO NORTH BRANCH PATAPSCO RIVER	39.4973	76.8698
212-95	BEAVER RUN	39.5385	76.9594
104-95	CRANBERRY BRANCH	39.6118	76.9546
124-95	ASPEN RUN	39.5603	76.8498
121-95	DEEP RUN	39.5647	76.8691
323-95	BEAVER RUN	39.5153	76.9327
208-96	UNNAMED TRIBUTARY TO LIBERTY RESERVOIR	39.4110	76.9240
209-96	MIDDLE RUN	39.4660	76.9120
309-96	MORGAN RUN	39.4880	77.0130
118-96	ROARING RUN	39.5210	76.9010
302-96	NORTH BRANCH PATAPSCO RIVER	39.4970	76.8790
311-96	BEAVER RUN	39.4920	76.9020
127-96	UNNAMED TRIBUTARY TO LIBERTY RESERVOIR	39.4740	76.8970
305-96	PATAPSCO RIVER	39.5160	76.8820
224-96	EAST BRANCH PATAPSCO RIVER	39.5500	76.8870
210-96	BEAVER RUN	39.5390	76.9600
201-96	EAST BRANCH PATAPSCO RIVER	39.5810	76.8920
229-96	EAST BRANCH PATAPSCO RIVER	39.5890	76.8860
121-96	UNNAMED TRIBUTARY TO LITTLE MORGAN RUN	39.4200	76.9670
219-96	EAST BRANCH OF PATAPSCO RIVER	39.6140	76.8840
321-96	MORGAN RUN	39.4530	76.9570
123-96	MORGAN RUN	39.5310	77.0350
320-96	NORTH BRANCH PATAPSCO RIVER	39.5260	76.8770
323-96	BEAVER RUN	39.5060	76.9290
101C-00	TIMBER RUN	39.4384	76.8672
101-00	KEYSERS RUN	39.4697	76.8593
102C-00	TIMBER RUN	39.4402	76.8636

103C-00	COOKS BRANCH	39.4376	76.8679
104-00	DEEP RUN	39.5865	76.8529
105C-00	STILLWATER CREEK	39.4017	76.9214
110-00	MIDDLE RUN	39.4940	76.9481
111-00	MIDDLE RUN	39.5040	76.9485
113-00	LIBERTY RESERVOIR	39.4955	76.8523
115-00	ROARING RUN	39.5182	76.8979
117-00	LIBERTY RESERVOIR	39.4965	76.8559
119-00	MIDDLE RUN	39.4790	76.9412
202-00	EAST BRANCH PATAPSCO RIVER	39.5608	76.8937
203-00	MORGAN RUN	39.4838	77.0113
204C-00	COOKS BRANCH	39.4378	76.8720
207-00	DEEP RUN	39.5843	76.8564
209-00	JOE BRANCH	39.4897	76.9866
212-00	NORRIS RUN	39.4576	76.8492
216-00	LITTLE MORGAN RUN	39.5273	77.0167
303-00	MORGAN RUN	39.4520	76.9526
318-00	MORGAN RUN	39.4765	76.9962

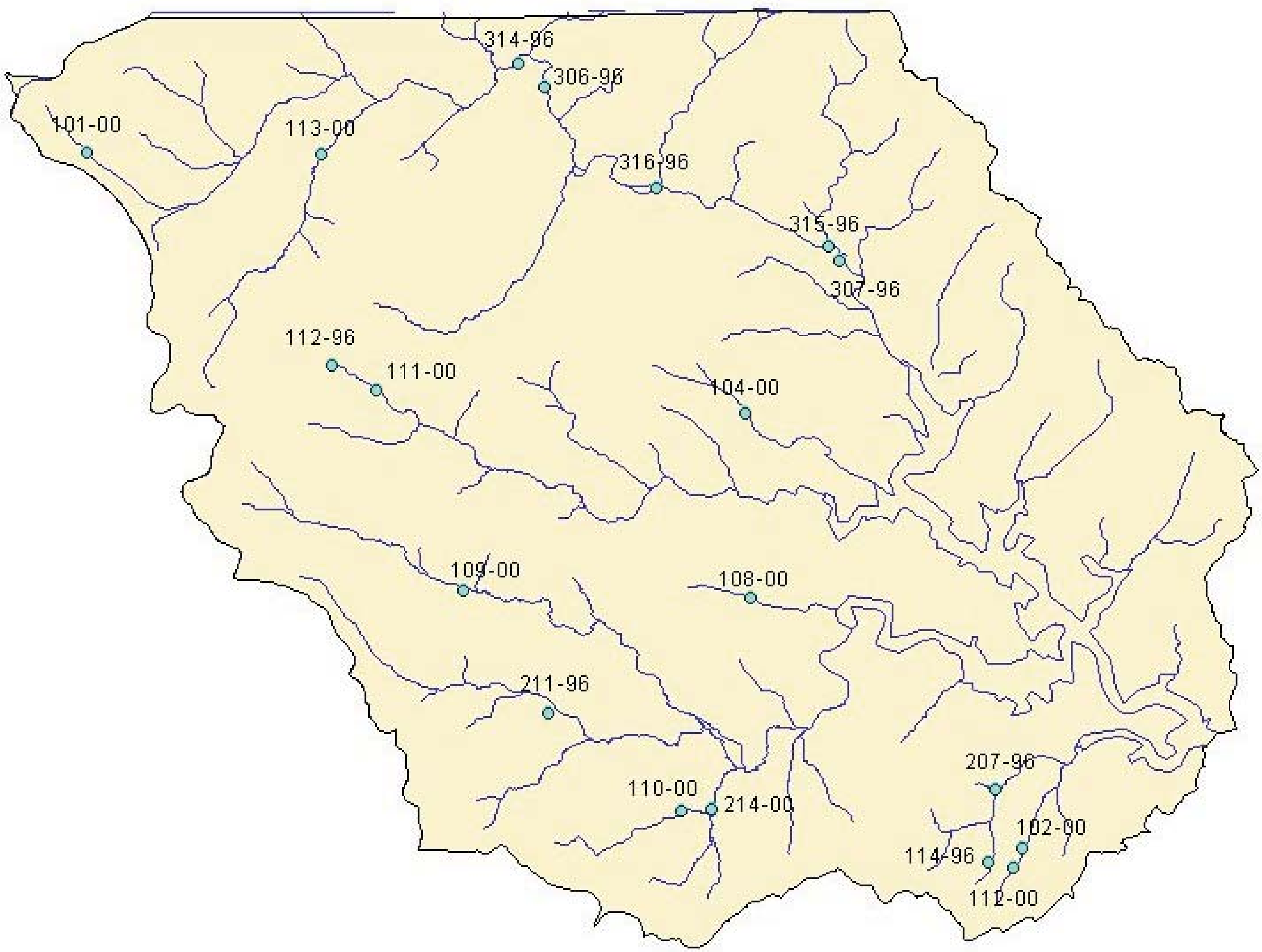
Site	Stream Name	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
Mattawoman Creek Watershed			
314-95	MATTAWOMAN CREEK	38.5823	77.0977
222-95	MATTAWOMAN CREEK	38.6013	77.0568
211-95	OLD WOMANS RUN	38.5975	77.0389
221-95	OLD WOMANS RUN	38.5960	77.0202
220-95	MATTAWOMAN CREEK	38.6311	77.0387
209-95	MATTAWOMAN CREEK	38.6549	76.8946
115-99	UNNAMED TRIBUTARY TO MATTAWOMAN CREEK	38.5851	77.1850
111-99	UNNAMED TRIBUTARY TO MATTAWOMAN CREEK	38.6169	77.0913
103-99	TIMOTHY BRANCH	38.6772	76.8829
205-99	MATTAWOMAN CREEK	38.6530	77.0016
105-99	UNNAMED TRIBUTARY TO MATTAWOMAN CREEK	38.6340	76.9063
109-99	UNNAMED TRIBUTARY TO MATTAWOMAN CREEK		
110-99	UNNAMED TRIBUTARY TO MATTAWOMAN CREEK	38.5573	77.0746
104-99	UNNAMED TRIBUTARY TO MATTAWOMAN CREEK	38.6739	76.9017
101-99	UNNAMED TRIBUTARY TO MATTAWOMAN CREEK	38.6749	76.8505
106-99	UNNAMED TRIBUTARY TO MATTAWOMAN CREEK	38.7880	76.9206
202-99	MATTAWOMAN CREEK	38.5228	76.8540
114-99	UNNAMED TRIBUTARY TO MATTAWOMAN CREEK	38.5383	77.1839
113-99	UNNAMED TRIBUTARY TO MATTAWOMAN CREEK	38.5538	77.1838
209-99	JENKINS RUN	38.5693	77.0923
108-99	PINEY BR MATTAWOMAN CREEK	38.6510	76.9694
207-99	OLD WOMAN'S RUN	38.5915	77.0028
112-99	MARBURY RUN	38.5679	77.1500
303-99	MATTAWOMAN CREEK	38.5865	77.1097
206-99	UNNAMED TRIBUTARY TO MATTAWOMAN CREEK	38.6173	77.0500
301-99	MATTAWOMAN CREEK	38.5756	77.0699
203-99	MATTAWOMAN CREEK	38.6523	76.9249
204-99	MATTAWOMAN CREEK	38.6552	76.9538
033-00	MATTAWOMAN CREEK	38.5822	77.0977
104-00	UNNAMED TRIBUTARY TO MATTAWOMAN CREEK	38.5692	77.0559
105-00	MATTAWOMAN CREEK	38.6673	76.9357
108-00	MATTAWOMAN CREEK	38.6591	76.9373
109-00	MATTAWOMAN CREEK	38.6284	77.0901
115-00	MATTAWOMAN CREEK	38.6283	77.0798
117-00	MATTAWOMAN CREEK	38.5393	77.1703
210-00	PINEY BRANCH	38.6548	76.9820
212-00	MATTAWOMAN CREEK	38.5428	77.1859
216-00	PINEY BRANCH	38.6520	76.9770
320-00	MATTAWOMAN CREEK	38.6525	76.9142

Site	Stream Name	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
Prettyboy Reservoir Watershed			
114-96	PRETTYBOY BRANCH	39.6030	76.7470
211-96	MURPHY RUN	39.6230	76.8260
307-96	GUNPOWDER FALLS	39.6860	76.7740
315-96	GUNPOWDER FALLS	39.6880	76.7760
207-96	PRETTYBOY BRANCH	39.6130	76.7460
316-96	GUNPOWDER FALLS	39.6960	76.8070
314-96	UNNAMED TRIBUTARY TO LITTLE FALLS RUN	39.7130	76.8310
306-96	GUNPOWDER FALLS	39.7100	76.8270
112-96	UNNAMED TRIBUTARY TO GRAVES RUN	39.6720	76.8650
101-00	SOUTH BRANCH GUNPOWDER FALLS	39.7011	76.9089
102-00	PRETTYBOY BRANCH	39.6046	76.7414
104-00	POPLAR RUN	39.6648	76.7909
108-00	COMPASS RUN	39.6393	76.7901
109-00	GEORGE'S RUN	39.6405	76.8415
110-00	PEGGY'S RUN	39.6099	76.8025
111-00	GRAVE RUN	39.6683	76.8572
112-00	PRETTYBOY BRANCH	39.6018	76.7432
113-00	SOUTH BRANCH GUNPOWDER FALLS	39.7009	76.8670
214-00	PEGGY'S RUN	39.6101	76.7971

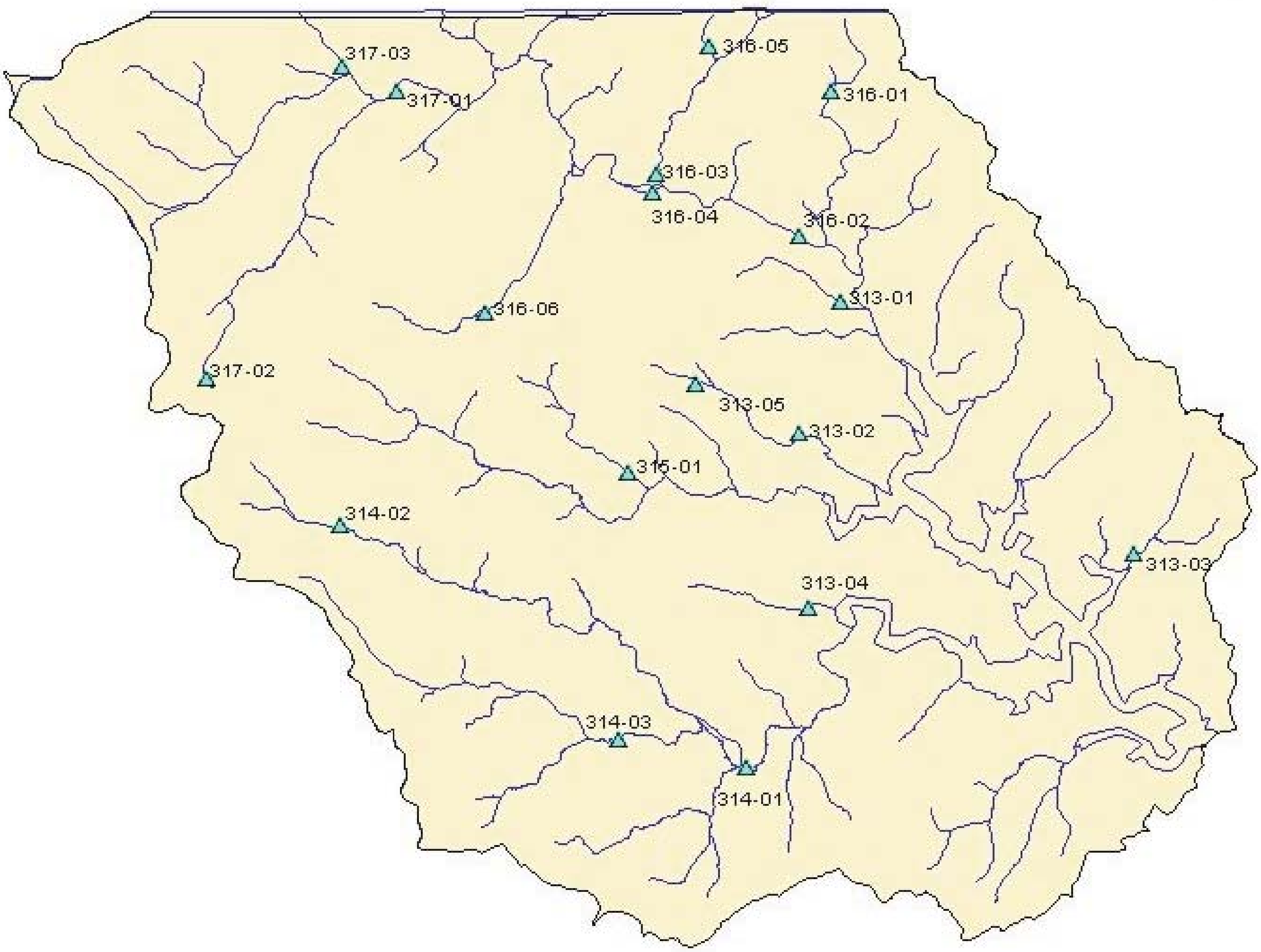


MBSS site names and locations in Liberty Reservoir watershed
sampled in 1995, 1996, and 2000.

Stream Waders site names and locations in Liberty Reservoir Watershed sampled in 2000.

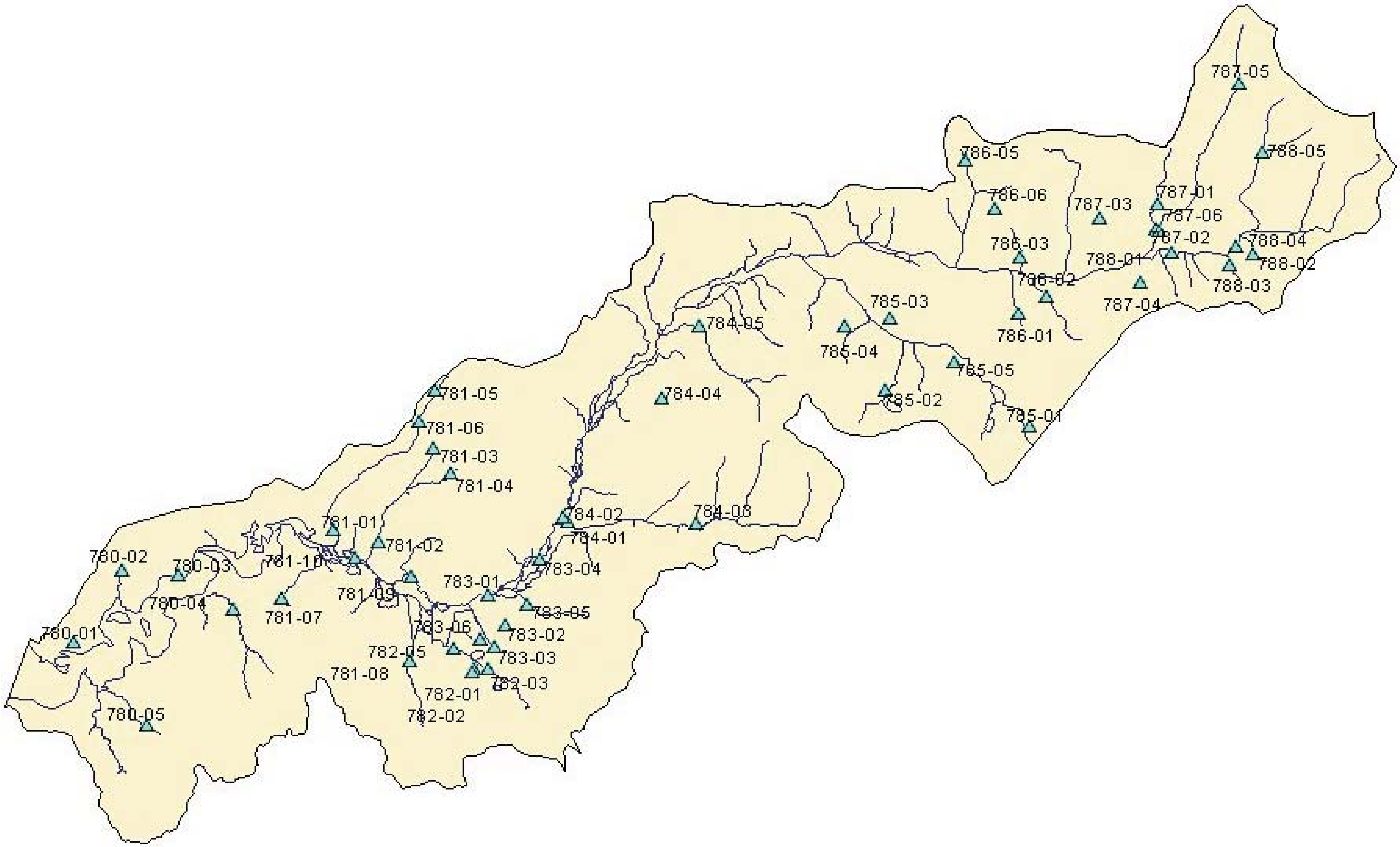


MBSS site names and locations in Prettyboy Reservoir watershed sampled in 1996 and 2000.



Stream Waders site names and locations in Prettyboy watershed in 2000.

MBSS site names and locations in Mattawoman Creek sampled in 1995, 1999, and 2000.



Stream Waders site names and locations in Mattawoman Creek Watershed sampled in 2000.